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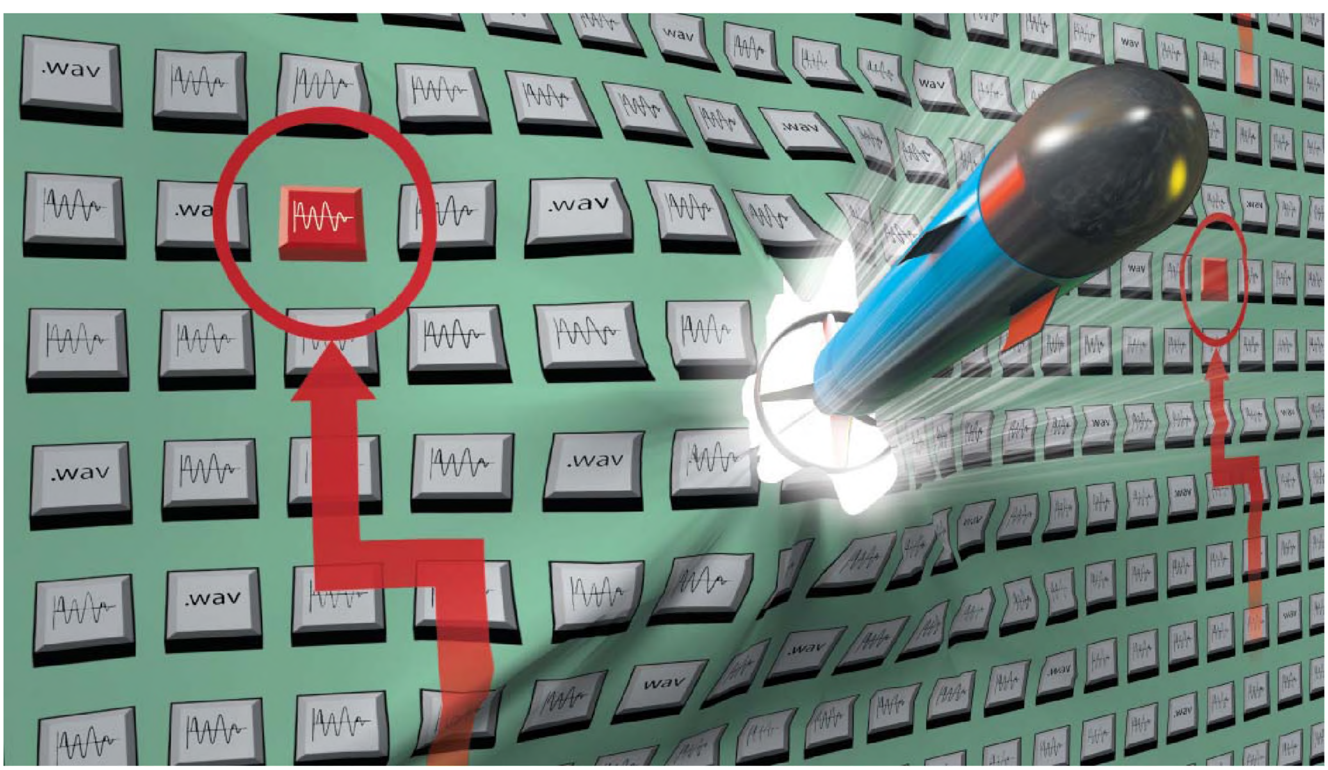

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PRESIDENT'S MESSAGE / MESSAGE DU PRÉSIDENT

This is my first opportunity to provide editorial comments for Canadian Acoustics as incoming President of the CAA. I would like to thank and express my sincere appreciation to Stan Dosso for running a very smooth and effective operation for the past four years. Stan provided a very engaging style of leadership with the rest of the Executive, the Board of Directors (BoD) and the wider CAA community, and it is a style I hope I will be able to emulate. Fortunately, he will remain in the CAA Executive team as our Past President and contribute further (I am sure) to the affairs of our Association. I am also extremely lucky to be supported by three very experienced and capable Executive members in our Secretary David Quirt, our Treasurer Dalila Giusti and our Journal Editor Ramani Ramakrishnan. As has been said several times before, much of the work in running the daily operations of the Association rests on their shoulders. I would also like to introduce our two new elected BoD members, Jérémie Voix from Sonomax Hearing Healthcare Inc., and Frank Russo from Ryerson University. Frank will also replace me as the new Awards Coordinator for the Association.

Just recently, we have enjoyed a very well attended and successful Acoustics Week in Canada (AWC) 2007 conference at Concordia University in Montreal, which included some 100 technical papers in all areas of acoustics, three excellent plenary presentations, one captivating Banquet dinner talk and a very special musical event. I noted an exceptionally large contingent of students at the conference, both presenters and attendees, and this bodes well for the future of the Association. Many thanks to Rama Bhat, the Conference Chair, and Kamran Siddiqui, Muthukumaran Packirisamy, Sivakumar Narayanswamy, Zhi Chen and Wenfang Xie and the others in the Organizing Committee. AWC 2008 will be held in Vancouver and is in the capable hands of Murray Hodgson and his organizing team. I am sure we can look forward to a very interesting conference again next year. Stay tuned to Canadian Acoustics and the CAA website at www.caa-aca.ca for more information.

Finally, if you read through the minutes of the last BoD meeting and AGM reproduced in this issue, you will notice that the CAA is embarking in at least two very important projects. Firstly, a subcommittee is looking at ways to improve the daily operations of the Association by implementing online membership payments and management via the website. Secondly, our Editor is actively looking at ways to make the back issues of our Journal online to increase its visibility and accessibility worldwide. Online trial issues should be posted shortly. As these projects progress, our website will increasingly become a major focal point for our Association. In this respect, I would like to thank Dave Stredulinsky for all the hard work he has done in improving our website over the past several years, often quietly but always effectively, and this includes a major contribution to the recent AWC confer-

À titre de nouveau président de l'ACA, c'est ma première chance d'écrire un éditorial pour l'Acoustique Canadienne. J'aimerais dès le départ exprimer ma sincère reconnaissance envers Stan Dosso et le remercier d'avoir assuré une gestion efficace et sans heurt de l'ACA au cours des quatre dernières années. Stan a démontré un style de présidence très engageant envers les membres du comité exécutif, du conseil d'administration et de l'ACA dans son ensemble dont j'espère pouvoir imiter. Fort heureusement, Stan demeure membre du comité exécutif à titre de président sortant et il continuera à contribuer (j'en suis certain) au développement de notre Association. Je suis aussi très chanceux d'être soutenu par trois membres exécutifs exercés, soit notre Secrétaire David Quirt, notre Trésorière Dalila Giusti et notre Rédacteur en chef Ramani Ramakrishnan. Tel que mentionné à maintes reprises dans le passé, le bon fonctionnement de notre Association repose en grande partie sur leurs épaules. J'aimerais aussi profiter de l'occasion pour vous présenter deux nouveaux membres élus du conseil d'administration. Il s'agit de Jérémie Voix de Sonomax Hearing Healthcare Inc. et de Frank Russo de l'Université Ryerson. Frank me remplacera aussi à titre de Coordonnateur des prix pour l'Association.

Tout récemment, plusieurs d'entre nous avons participé à la Semaine Canadienne d'acoustique 2007 à l'Université Concordia à Montréal, un congrès des plus réussi avec une centaine d'exposés techniques couvrant tous les domaines de l'acoustique, trois excellentes présentations plénières, une conférence au banquet annuel des plus captivante et une soirée musicale bien spéciale. J'ai noté la présence d'un nombre sans pareil d'étudiants au congrès, tant au niveau des présentateurs que dans l'auditoire, ce qui présage bien pour le futur de l'Association. Maints remerciements à Rama Bhat, président du congrès, Kamran Siddiqui, Muthukumaran Packirisamy, Sivakumar Narayanswamy, Zhi Chen et Wenfang Xie, ainsi qu'aux autres membres du comité organisateur. La Semaine Canadienne d'acoustique 2008 se tiendra à Vancouver et est entre mains sûres avec Murray Hodgson et son équipe. Nous pouvons anticiper un congrès des plus intéressant encore l'an prochain. Pour plus de renseignements, veuillez consulter l'Acoustique Canadienne et le site Internet de l'ACA au www.caa-aca.ca.

Finalement, si vous lisez les procès-verbaux du dernier conseil d'administration et de l'assemblée générale annuelle, disponibles dans cette parution de la revue, vous noterez que l'ACA amorce au moins deux projets d'envergure. Un sous-comité étudie présentement les façons d'améliorer la gestion quotidienne de l'Association en mettant en ligne plusieurs opérations telles que le paiement des frais d'adhésion par les membres et la gestion des bases de données. Aussi, notre Rédacteur en chef explore activement les façons de rendre disponible en ligne les parutions antérieures de la revue Acoustique Canadienne afin d'hausser sa visibilité sur ence websites and our online conference abstract and paper submission system. Our new webmaster is Geoff Morrison. I can already attest that Geoff is highly enthusiastic in assuming this role and that he already made very substantial contributions to the website over the past few months. Our website is more complete and well rounded as it has ever been, especially on the French side. You can expect further improvements in the coming months.

These are quite exciting times for the CAA. As you know, it is a completely volunteering effort. Do not hesitate to contact any of us members of the Executive or BoD if you want to contribute more actively to the CAA. This is your Association!

Christian Giguère
CAA President

le plan mondial. Quelques numéros devraient sous peu être disponibles en ligne. À mesure que ces projets progresseront, notre site Internet deviendra de plus en plus une porte d'entrée incontournable pour l'Association. À cet égard, je tiens à souligner le travail ardu et efficace de Dave Stredulinsky au cours des dernières années afin d'améliorer notre site Internet, incluant des contributions majeures aux sites des récents congrès et au processus de soumission en ligne des sommaires et des articles de deux pages des congrès. Notre nouveau webmestre est Geoff Morrison. Je peux d'ores et déjà attester que Geoff assume son rôle avec enthousiasme et qu'il a déjà contribué de façon substantielle au site Internet au cours des derniers mois. Notre site est plus complet que jamais, surtout pour son volet français. Vous pouvez vous attendre à d'autres améliorations dans les mois à venir.

Il s'agit d'une période très excitante pour l'ACA. Comme vous le savez, nous progressons grâce à des efforts complètement volontaires de la part de nos membres, alors n'hésitez pas à contacter un membre du comité exécutif ou du conseil d'administration si vous souhaitez contribuer plus activement à l'ACA. C'est votre Association!

Christian Giguère
Président de l'ACA

Segmentation En Locuteurs De Documents Audio: Une Nouvelle Approche Basée Sur Les Méthodes A Vecteurs Support Mono Classe

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SOMMAIRE

Avec l'augmentation récente et continue du volume d'archiv es sonores (radio, TV, Web, ...), il devient désormais indispensable de trouver des méthodes efficaces qui permettent de faciliter la recherche d'informations dans les grandes bases de données. Ainsi, on associe aux fichiers audio numérisés des fichiers textuels (fichiers index), de moindre complexité que le fichier signal original, mais contenant néanmoins un résumé des informations recherchées dans ce signal. 45 minutes de parole, 1 minute de musique, 10 locuteurs (6 hommes et 4 femmes) sont un exemple d'informations pertinentes. Ces fichiers d'index stockés en même temps que le signal original, seront d'un apport considérable lors de l'étape de recherche d'informations, permettant alors u n accès direct et immédiat à l'information recherchée. Dans le cas où l'on voudrait savoir qui parle et q uand dans un document sonore, la clé d'indexation est alors le locuteur. Un système d'indexatio n par locuteurs peut servi! r également comme étape préliminaire à des tâches de transcription ou de suivi de locuteurs et représente souvent un facteur important pour l'amélioration des perfo rmances des systèmes de reconnaissance automatique de la parole. Une étape préalable indispensable d'un système d'indexation par locuteurs est la segmentation en locuteurs. Celle-ci consiste à réaliser deux tâches séquentielles: la première étape permet de découper le signal paramétré en intervalles ou segments correspondants à des tours de parole de locuteurs, c'est à dire obtenir des segments les plus longs possibles homogènes en termes de locuteur, puis la deuxième étape consiste à regrouper les segments appartenant à un même locuteur.

Cet article présente une nouvelle approche originale pour la segmentation en locuteurs d'enregistrements audio. Il s'agit de l'application d'un a lgorithme basé sur l'utilisation des Méthodes à Vecteurs Support mono-classe (SVM-1), introduit récemment par l'un des auteurs, pour la détection de ruptures puis le regroupement de segments correspondant à l'intervention des différents locuteurs. Nous montrons à travers de nombreuses expériences sur deux bases de signaux d'enregistrements radiodiffusées, la pertinence de cette méthode et son comportement comparés par rapport à la méthode classique à base du rapport de vraisemblance généralisé utilisant le critère d'information bayésien (RVG-BIC).

ABSTRACT

With recent and continued increases in the number of available sound archives (radio, TV, Web,...), effective methods must be established to facilitate the process of searching for information within massive databases. Of less complexity than the original sound file but nevertheless containing a summary of important information pertaining to the signal, text files (index files) are linked to the digital sound files. An example of relevant information found in the text file is as follows: 45 minutes of speech, 1 minute of music, 10 speakers (6 men and 4 women). These index files, stored with the original signal, will contribute considerably to the information retrieval process, allowing an immediate and direct access to the information sought. If one would like to know who speaks and when in a sound file, the index key is hence the speaker. A preliminary stage of a speaker indexing system is speaker diarization. State-of-the-art speaker diarization techniques require two main steps: speaker turn detection which consists of detecting speaker turn times, that is boundaries of audio file segments where only one speaker is present, followed by a clustering step which consists of labelling the previous segments in terms of speakers. These two stages require a metric to be defined in order to compare and groups speech segments. This paper presents a novel approach for the speaker diarization of audio recordings. The proposed approach uses a metric based on one-class Support Vector Machines (SVM-1), introduced recently by one of the authors, for the speaker change detection and clustering tasks. Through many experiments using two databases of broadcast recordings, we demonstrate the relevance and superiority of this approach compared to the traditional method based on the generalized likelihood ratio using bayesian information criterion (RVG-BIC).

1 INTRODUCTION

Avec la multiplication de sources de données multimédia et le développement des techniques de numérisation de l'information, nous assistons à une explosion des bases de données d'archivage. De ce fait se pose un problème crucial: Comment accéder facilement et rapidement à l'information recherchée ? Ces deux critères (rapidité et facilité d'accès) sont indispensables pour toute requête d'utilisateur.

L'indexation en locuteur d'un signal sonore consiste à structurer ce signal selon l'information véhiculée par le locuteur. Dans ce contexte, la segmentation en locuteur constitue une étape préalable et déterminante pour la suite du processus d'indexation. Elle consiste à d'abord découper le signal audio en zones homogènes contenant uniquement les informations relatives à un seul locuteur. Cette étape est suivie du regroupement (clustering) de ces segments afin d'assembler les zones appartenant à un seul locuteur.

Ce problème a déjà fait l'objet de nombreuses études (voir par exemple [9, 10, 14, 16] et dans les références qui y sont indiqués). Les techniques standard utilisent généralement des descripteurs acoustiques (souvent des MFCC et leurs dérivées) puis appliquent deux fenêtres d'analyse glissantes sur les données de part et d'autre de l'instant courant. Etant donné les vecteurs acoustiques $\mathbf{x}(n)$, $n = 1, 2, \ldots$, la fenêtre d'analyse située avant l'instant d'analyse n définit l'ensemble passé immédiat $\mathsf{X}_\mathsf{p}(n) = \{\mathbf{x}(n - m_\mathsf{p}), \ldots, \mathbf{x}(n - 1)\}$ de m_p vecteurs acoustiques, tandis que l'autre fenêtre contient m_f vecteurs acoustiques représentant l'ensemble futur immédiat $\mathsf{X}_\mathsf{f}(n) = \{\mathbf{x}(n+1), \ldots, \mathbf{x}(n+m_\mathsf{f})\}$. L'objectif de ces techniques classiques est de comparer les ensembles $\mathsf{X}_\mathsf{p}(n)$ et $\mathsf{X}_\mathsf{f}(n)$ en évaluant une distance (ou une mesure de similarité) entre ces deux ensembles de données. Ceci est réalisé au moyen de méthodes à base de rapport de vraisemblance généralisé (RVG) soit directement [10] ou indirectement comme dans l'approche par critère d'information bayésien (BIC) notée RVG-BIC et adoptée comme référence dans ce papier [4]. Les méthodes à base de RVG-BIC nécessitent la connaissance d'un modèle de la distribution de probabilité des données $\mathbf{x}(n)$. Les modèles gaussien ou mélange de gaussiennes ont été largement exploités dans ce cadre. Bien que ces méthodes aient souvent donné des résultats satisfaisants, l'adéquation du modèle aux données réelles constitue néanmoins une hypothèse très forte et non généralisable. D'autre part, les méthodes inspirées du RVG-BIC souffrent d'un grand taux de fausse alarme pour de courtes interventions ($\leq$ 2-5 secondes) et sont aussi gourmandes en temps de calcul [14]. Les méthodes indirectes [4], appelées aussi méthodes pas à pas, opèrent en deux étapes :

1. Détection de ruptures acoustiques: Cette étape consiste à segmenter le signal (ou sa version paramétré) en plages acoustiquement homogènes, dans le sens que chaque segment contient un seul et unique locuteur. A l'issue de cette étape on obtient les instants correspondants aux frontières de ces segments.

2. Regroupement de segments homogènes : Cette étape consiste à regrouper les segments appartenant à un même locuteur. Autrement dit, le cluster correspondant à un locuteur donné ne doit contenir que les interventions (segments) appartenant à ce locuteur et tous les segments relatifs à ce locuteur doivent se trouver dans ce même cluster .

Les méthodes intégrées [8] consistent à fusionner les deux étapes dans le sens qu'elles consistent à détecter puis regrouper les locuteurs au fur et à mesure du déroulement du signal.

Dans cet article, nous suivrons le formalisme des méthodes pas à pas et nous proposons d'appliquer l'algorithme basé sur une méthode à noyau introduite dans [5] aux tâches de détection de ruptures et de regroupement dont le résultat d'ensemble est connu sous le vocable de segmentation en locuteurs [6]. Différemment des approches citées précédemment, notre approche exploite un algorithme à base de Méthodes à Vecteurs de Support mono-classe (SVM-1) dont la finalité est de comparer les ensembles $\mathsf{X}_\mathsf{p}(n)$ et $\mathsf{X}_\mathsf{f}(n)$ à chaque instant d'analyse au moyen d'une mesure de similarité. Dans ce sens, notre méthode reste semblable aux méthodes classiques à base de RVG, néanmoins notre approche exploite les informations extraites de l'entraînement de deux (SVM-1), dont l'avantage principal est de contrôler la complexité du modèle ajusté aux données et de prendre en compte l'information paramétrée selon diverses configurations et tailles des vecteurs acoustiques.

Le reste du papier est structuré de la façon suivante: Dans la section suivante, nous rappelons le principe de l'algorithme de détection de rupture basé (SVM-1), puis la section 3 présente la méthodologie d'application à la segmentation en locuteurs. La section 4 est particulèrement privilegiée puisqu'elle présente les résultats d'application de notre méthode aux signaux réels issus de deux bases de données radiophoniques en comparaison avec la méthode RVG-BIC. Nous y détaillons le choix des paramètres de détection de ruptures et de regroupement. Finalement la dernière section 5 présente les conclusions et perspectives.

2 LA DETECTION DE RUPTURE BASEE SUR SVM-1

Nous partons de l'hypothèse que les vecteurs acoustiques $\mathbf{x}_1, \ldots, \mathbf{x}_m$ sont générés identiquement et indépendemment par une distribution de probabilité (ddp) inconnue $\mathsf{p}(\mathbf{x})$. Le principe de l'algorithme Kernel Change Detection (KCD) développé dans [5] est de comparer les ensembles $\mathsf{X}_\mathsf{p}(n)$ et $\mathsf{X}_\mathsf{f}(n)$ au travers de la comparaison de leur support de ddp. On définit le support d'une ddp S^λ par l'ensemble des points de l'espace des vecteurs acoustiques $\mathcal{X}$ telle que $\mathsf{p}(\mathbf{x}) \geq \lambda$, avec λ une constante positive quelconque. Lorsque $\mathcal{X} = \mathbb{R}^d$ et $\mathsf{p}(\mathbf{x})$ est une distribution gaussienne multivariée de dimension d, S^λ est une ellipsoïde de dimension d. Dans le cas le plus général, le support de densité peut avoir une configuration géométrique quelconque (généralement lisse). L'algorithme KCD applique un modèle SVM-1 aux données afin d'estimer leur support de ddp, ce que nous détaillons dans la section suivante.

2.1 Les Méthodes à Vecteurs Support mono-classe (SVM-1)

Soit une fonction réelle symétrique appelée noyau définie dans $\mathcal{X}$. Dans la suite, nous considérons un noyau de forme gaussien, comme suit:

$$\mathsf{k}(\mathbf{x}_1, \mathbf{x}_2) = \exp -\frac{1}{2\sigma^2}\|\mathbf{x}_1 - \mathbf{x}_2\|^2_{\mathcal{X}} \quad (1)$$

avec $\|\cdot\|^2_{\mathcal{X}}$ est une norme définie sur $\mathcal{X}$. Le modèle SVM-1 estime le support de la ddp comme suit :

$$\mathsf{S}^{\lambda} = \{\mathbf{x} \in \mathcal{X} | \mathsf{f}^{\lambda}(\mathbf{x}) + b \geq 0\} \quad (2)$$

Ce problème d'estimation du support de la ddp revient à estimer une fonction dans l'espace augmenté $\mathcal{H}$ (hilbertien et à noyau reproductible induit par $\mathsf{k}(\mathbf{x}_1, \mathbf{x}_2)$) , proche du support de la ddp recherchée. On montre dans [12] que les fonctions minimisant le risque régularisé s'écrivent en fonction de $\mathbf{x}$ comme :

$$\mathsf{f}^{\lambda}(\mathbf{x}) + b = \sum_{i=1}^{m} \alpha_i \mathsf{k}(\mathbf{x}, \mathbf{x}_i) + b \quad (3)$$

les coefficients de pondération α_i sont dénommés les multiplicateurs de lagrange. Le paramètre ν (réel positif) joue un rôle de contrôle des vecteurs supports. Ainsi, choisir $\nu = 0.2$ équivaut à admettre 20% de vecteurs acoustiques dans X comme marginaux [1]. A ce problème d'optimisation correspond un problème dual plus simple à résoudre puisque quadratique avec des contraintes linéaires:

$$\begin{array}{ll} \text{minimiser} & \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \alpha_i \alpha_j \mathsf{k}(\mathbf{x}_i, \mathbf{x}_j) \\ \text{par rapport à} & \{\alpha_1, \ldots, \alpha_m\} \\ \text{avec les contraintes : a)} & 0 \leq \alpha_i \leq \frac{1}{\nu m} \text{ t.q. } i = 1, \ldots, m \\ \text{et b)} & \sum_{i=1}^{m} \alpha_i = 1 \end{array} \quad (4)$$

le modèle SVM-1 admet une simple interprétation géométrique dans l'espace augmenté $\mathcal{H}$: premièrement, les vecteurs acoustiques dans $\mathcal{X}$ sont projetés vers $\mathcal{H}$ au moyen de l'application :$\mathbf{x} \rightarrow \mathsf{k}(\mathbf{x}, \cdot)$. Deuxièmement, les vecteurs acoustiques dans $\mathcal{H}$ sont de norme unitaire lorsque le noyau gaussien est choisi, car $\|\mathsf{k}(\mathbf{x}, \cdot)\|^2_{\mathcal{H}} = \langle \mathsf{k}(\mathbf{x}, \cdot), \mathsf{k}(\mathbf{x}, \cdot)\rangle_{\mathcal{H}} = \mathsf{k}(\mathbf{x}, \mathbf{x}) = 1$ (propriété du noyau reproductible dans l'espace hilbertien), ainsi ces vecteurs sont situés sur la surface d'une hypersphère de rayon unité. Troisièmement, la résolution de Eq. (4) peut se ramener à trouver dans $\mathcal{H}$ un hyperplan orthogonal à $\mathsf{f}(\cdot)$ tel que celui-ci serait le plus éloigné de l'origine, séparant ainsi les données d'apprentissage $\mathsf{k}(\mathbf{x}_i, \cdot)$ entre deux classes -voir figure 1.

[1] en anglais:outliers

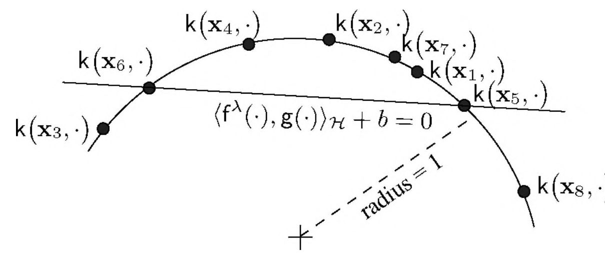

Figure 1: Interprétation géométrique du modèle SVM-1 dans $\mathcal{H}$. Les vecteurs acoustiques projetés $\mathsf{k}(\mathbf{x}_i, \cdot)$, $i = 1, \ldots, m$ sont situés sur une hypersphère de rayon unité. La fonction $\mathsf{f}^{\lambda}(\cdot)$ et b définissent un hyperplan d'équation $\langle \mathsf{f}^{\lambda}(\cdot), \mathsf{g}(\cdot)\rangle_{\mathcal{H}} + b = 0$. La majorité des données est située du côté de l'hyperplan ne comprenant pas l'origine de l'hypersphère. Les coefficients α_i correspondants sont nulles ($i \in \{1, 2, 4, 7\}$), tandis que les points marginaux $\mathsf{k}(\mathbf{x}_3, \cdot)$ et $\mathsf{k}(\mathbf{x}_8, \cdot)$ sont situés du côté de l'hyperplan comprenant l'origine $\alpha_3 = \alpha_8 = 1/\nu m$. Les points situés sur l'intersection de l'hyperplan et de l'hypersphère vérifient $0 < \alpha_i < 1/\nu m$ ($i \in \{5, 6\}$).

2.2 Une mesure de similarité basée sur SVM-1

Cette mesure est construite sur le principe que les ensembles $\mathsf{X}_\mathsf{p}(n)$ and $\mathsf{X}_\mathsf{f}(n)$ sont similaires si et seulement si les supports de densités estimés sont similaires selon un certain critère de similarité. Notons que, dans l'espace initial des données $\mathcal{X}$, la forme des contours de décision représentant $\mathsf{S}^{\nu}_\mathsf{p}(n)$ et $\mathsf{S}^{\nu}_\mathsf{f}(n)$ peuvent être complexes et discontinus, rendant ainsi la définition d'une mesure de similarité dans cet espace très difficile. Heureusement, l'interprétation géométrique des SVM-1 dans l'espace augmenté $\mathcal{H}$ permet d'en déduire une mesure très intuitive et simple à mettre en oeuvre : les quantités $\mathsf{S}^{\nu}_\mathsf{p}(n)$ et $\mathsf{S}^{\nu}_\mathsf{f}(n)$ correspondent géométriquement aux hypercercles résultants de l'intersection de l'hypersphère avec l'hyperplan, voir figure 1. Ainsi, la comparaison des quantités $\mathsf{S}^{\nu}_\mathsf{p}(n)$ et $\mathsf{S}^{\nu}_\mathsf{f}(n)$ dans l'espace initial des données $\mathcal{X}$ se ramène à une comparaison dans $\mathcal{H}$ en comparant les hypercercles correspondants dont les centres sont notés $\mathsf{c}^{\nu}_\mathsf{p}(n)$ et $\mathsf{c}^{\nu}_\mathsf{f}(n)$ et les arcs de cercle $\mathsf{r}^{\nu}_\mathsf{p}(n)$ et $\mathsf{r}^{\nu}_\mathsf{f}(n)$, voir figure 2.

La mesure de similarité basée sur notre algorithme est définie comme suit [5]:

$$\mathsf{D}^{\nu}(n) = \frac{\mathsf{d}(\mathsf{c}^{\nu}_\mathsf{p}(n), \mathsf{c}^{\nu}_\mathsf{f}(n))}{\mathsf{r}^{\nu}_\mathsf{p}(n) + \mathsf{r}^{\nu}_\mathsf{f}(n)} \quad (5)$$

Pratiquement, $\mathsf{D}^{\nu}(n)$ est calculée à partir des coefficients α_i de chaque support de densité $\mathsf{S}^{\nu}_\mathsf{p}(n)$ et $\mathsf{S}^{\nu}_\mathsf{f}(n)$, -voir l'article de F. Desobry et al. dans [5] pour les détails de calcul et de développement de cette mesure.

3 DETECTION DE CHANGEMENT DE LOCUTEURS

3.1 La détection de ruptures

Le processus de détection de ruptures basé sur l'algorithme KCD effectue séquentiellement les étapes suivantes :

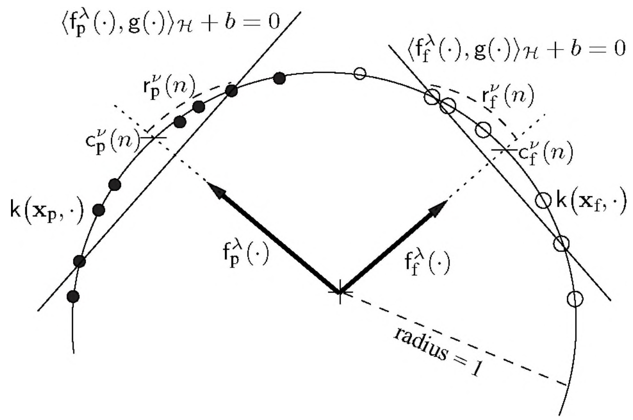

Figure 2: Interprétation géométrique de l'algorithme basé sur SVM-1. La situation représentée ici correspond à une détection de ruptures, car les hyperplans représentés par $f_p^\lambda(\cdot)$ (correspondant à l'ensemble passé immédiat – cercles pleins) et $f_f^\lambda(\cdot)$ (correspondants à l'ensemble futur immédiat – cercles vides) sont distinctement séparés, et la distance $d(c_p^\nu(n), c_f^\nu(n))$ est grande par rapport aux arcs $r_p^\nu(n)$ et $r_f^\nu(n)$.

1. **Paramétrisation acoustique**: Celle-ci est effectuée au moyen d'outils conventionnels tel que HTK Tools [15]. Cette étape est effectuée pour l'ensemble du signal.

2. **Entraînement des SVM-1** : Pour chaque instant n et consécutivement à la formation des ensembles $X_p(n)$ et $X_f(n)$ deux modèles SVM-1 sont entraînés en résolvant le problème (4) pour les deux ensembles. Pour réduire les charges de calculs et accélerer la procédure, la technique développée dans [3] peut être utilisée.

3. **évaluation de la mesure de similarité**: Comme dans toute technique de segmentation (détection de rupture), une rupture est détectée lorsque l'indice $D^\nu(n)$ définie dans Eq. (5) dépasse un seuil prédéterminé. Une autre approche consiste à calculer toute la courbe des distances puis choisir un seuil donné permettant d'estimer les instants de ruptures.

3.2 Le regroupement hiérarchique

Suite à la détection de ruptures, nous sommes en présence d'une collection d'objets (segments de paroles homogènes/locuteurs) et nous devons regrouper ces objets par classe (les locuteurs). Nous avons choisi de mettre en oeuvre le regroupement hiérarchique agglomératif qui consiste à considérer au départ chaque segment comme étant une classe et à chaque itération on réunit deux classes les plus proches au sens d'un critère, appelé critère de regroupement [4]. Dans ce cas ce critère est la mesure de similarité définie dans la section 2.2. Ce processus est réitéré jusqu'à l'obtention d'une classe unique. Nous obtenons à l'issue du regroupement un arbre de classification appelé dendrogramme. C'est la manière de parcourir l'arbre qui définit la partition finale.

4 EXPERIENCES ET RESULTATS

L'objectif de ces expériences est de conduire une étude comparative des performances de notre méthode par rapport à la méthode RVG-BIC prise comme référence. Ces expériences sont menées pour deux bases de données différentes. Le but poursuivi est d'abord de réaliser une étude comparative préliminaire avec une base de données locale (ALSIG) puis de mener une étude détaillée dont l'objectif est l'étude des performances de notre méthode en fonction du réglage de ses différents paramètres, c'est ce que nous avons réalisé avec la base de données (NISTDB) issue de la compagne d'évaluation NIST RT'03 [11].

4.1 Bases de données

Les signaux utilisés sont issus d'enregistrements d'émissions d'informations radiodiffusées (Broadcast News) de diverses stations locales algériennes et une base de données de stations radio américaines.

Pour la base de données locale (ALSIG) [13], les fichiers ont été enregistrés a partir du web au moyen du logiciel praat [1]. La segmentation de référence est obtenue également par annotation manuelle, une option offerte par le logiciel praat. Ces fichiers sonores sont structurés comme suit:

- 6 enregistrements radiodiffusées de la Radio Algérienne désignées par bndz1 à bndz6 de 10 mn chacun, en langues arabe et française.

- 4 fichiers sonores de durées 3 minutes chacun et pour lesquelles l'intervention moyenne de chaque locuteur est de 3 secondes en moyenne.

Les fichiers de la base NISTDB [11] se divisent en deux catégories: 6 fichiers de développement (dry run files) de 10 minutes environ chacun dédiés au réglage des paramètres et 3 fichiers d'évaluation (Eval files) de 30 minutes chacun.

4.2 Critères de Performances

Pour la base de données (ALSIG) utilisée pour une première évaluation de notre méthode, le critère de performance retenue est la mesure des erreurs d'insertions et d'omissions. Une erreur d'insertion se produit lorsque un changement de locuteur est détecté alors que celui-ci n'existe pas dans le fichier réel analysé. Une erreur d'omission correspond au fait de manquer de détecter un changement de locuteur alors que celui-ci existe. On l'appelle aussi l'erreur de détection manquée (DM). Notre méthode de segmentation en locuteurs étant conçu pour être insérée dans un système d'indexation global, dans ce cas une erreur d'insertion (ou fausse alarme) (FA) dûe à une sursegmentation s'avère toujours moins critique qu'une erreur de détection manquée due à une sous-segmentation. Ceci s'explique par le fait que l'étage de détection de rupture est suivi séquentiellement par l'étage de regroupement (clustering) des segments appartenant au même locuteur, et par conséquent une erreur de fausse alarme est souvent rattrapée et corrigée lors de l'étape de regroupement.

Dans ce cadre, une segmentation de référence est absolument nécessaire pour évaluer ce genre d'erreurs. Cependant la précision de détection des instants de changement dépend de la construction de la segmentation de référence qui est entachée d'une erreur systématique due à la subjectivité d'évaluation d'un instant de changement de locuteur selon l'expérimentateur. Ainsi, un instant candidat est déclaré erreur d'insertion ou erreur de fausse alarme si on ne trouve pas un instant de référence qui l'entoure dans un intervalle de confiance prédéfini. De même, l'absence d'un instant candidat (généré par notre système) autour d'un instant de référence correspond à une erreur d'omission ou détection manquée.

Pour la base (NISTDB), le critère de performance établi et fourni par l'institut NIST est le Speaker Diarization Error ou Diarization Error Rate (DER) obtenu par un script en langage perl (voir [9] pour d'amples détails).

Selon ce protocole d'expérimentation, Il s'agit de présenter le résultat de la segmentation issu du système proposé, selon le format défini par NIST. Ce fichier constitue une entrée au script fourni conjointement au fichier de référence. Le résultat est un fichier texte fournissant le DER (en %).

4.3 Résultats d'expériences sur la base ALSIG

Les résultats reportés dans la table 1 mettent en évidence les performances comparés de notre algorithme KCD et la méthode de référence basée sur le Rapport de Vraisemblance Généralisé utilisant le critère d'information bayésien (RVG-BIC) . Les conditions d'expérience (initialisation des paramètres) communes aux deux méthodes sont : La paramétrisation acoustique est effectuée au moyen de l'outil HTK et les descripteurs utilisés sont les coefficients MFCC au nombre de 16 (pas de coefficient Co) avec une fenêtre de Hamming de 20 ms et un recouvrement de 50%. La taille des fenêtres glissantes sur les données est fixée à $m = m_{\mathrm{p}}$=m_{f}= 1.5 secondes avec un pas de progression Δ_n= 0.1 secondes. Les paramètres spécifiques à chaque méthode sont les suivantes: Pour la méthode RVG-BIC, les données passées et futurs par rapport à l'instant d'analyse sont modélisés comme une mono-gaussienne avec une matrice de covariance diagonale et le paramètre de regroupement est fixe à λreg= 1.5 [4]. Pour notre méthode KCD, il y a lieu de préciser le paramètre du noyau gaussien σ que nous avons initialisé à σ =1. Les fichiers sonores bndz1 à bndz6 contiennent respectivement de 15 points à 42 points de ruptures relatifs à des tours de parole des locuteurs intervenant dans l'enregistrement audio. Les résultats montrent que la méthode KCD réalise de meilleurs performances en terme de taux de DM. Cependant le taux de FA reste comparable par rapport à la méthode de référence.

L'objectif de l'expérience suivante est de montrer que notre algorithme permet de détecter des changements de locuteurs, même dans des situations où la méthode RVG-BIC ne donne pas de bons résultats [14]. L'expérience dont les résultats sont portés dans la table 2 tendent a démontrer la supériorité des performances de notre méthode pour des fichiers sonores pour lesquelles l'intervention moyenne de chaque locuteur est très courte (3 secondes). La paramétrisation est la même que pour l'expérience précédente. Les autres paramètres communs restent les mêmes, alors que les paramètres spécifiques de chaque méthode sont tels que: Pour RVG-BIC: λreg=1. Pour KCD, σ = 1. Les résultats préliminaires, montrent néanmoins des performances supérieures de notre méthode par rapport à la méthode de référence. Le Taux de FA reste cependant important même pour notre méthode.

Ces expériences préliminaires montrent la nécessité d'ajuster les paramètres spécifiques à chaque méthode en fonction des données à traiter et des expériences. Pour cela nous avons considéré une base de données plus importante et reconnue par la communauté scientifique active dans ce domaine pour mener une étude détaillée de notre méthode en fonction de ses paramètres et tenant compte de diverses paramétrisations acoustiques.

4.4 Expériences sur les signaux de développement de la base NIST

Afin de régler les paramètres de notre algorithme pour les tâches de détection de ruptures et de regroupement nous utilisons les six fichiers de développement pris séparément et le score global est la moyenne sur l'ensemble des fichiers. Pour les expériences concernant cette catégorie de fichiers, la paramétrisation utilisée est de 16 coefficients MFCC. Ce choix initial, à priori arbitraire est motivé par le fait que le type de paramétrisation et leur nombre est souvent utilisé dans la méthode de référence (RVG-BIC) et donne des résultats satisfaisants.

Sélection de paramètres

Les paramètres pertinents de notre algorithme objet de cette étude de sélection sont : $m = m_{\mathrm{p}}$=m_{f} (taille de l'ensemble $\mathsf{X}_{\mathrm{p}}(n)$ et de $\mathsf{X}_{\mathrm{f}}(n)$ que nous supposons égaux) et le pas de progression Δ_n de ces ensembles appelés communément fenêtres glissantes précédent et succédant à l'instant d'analyse n. Ces deux paramètres m et Δ_n sont communs avec la méthode de référence RVG-BIC. Aux fins de comparaison des deux méthodes nous avons fixé les mêmes valeurs pour ces deux paramètres.

Notre algorithme utilise un paramètre additionnel relatif au noyau, assurant le contrôle de la corrélation des points voisins dans l'espace augmenté $\mathcal{H}$. Dans le cas du noyau gaussien ce paramètre est l'ecart-type σ.

La table 3 montre l'évolution du DER en fonction de la variation de σ. Le minimum d'erreur est atteint pour σ =0.51, et vaut 10.73%. Les autres paramètres utilisés pour cette expérience sont fixés comme suit: $m = m_{\mathrm{p}}$=m_{f}=win=1.5s et Δ_n=0.2s, qui sont des paramètres adéquats pour les deux méthodes en comparaison. Le paramètre ν =0.1 traduit une tolérance maximale de 10% des vecteurs support.

Les tables 4 et 5 résument les variations de la taille des fenêtres adjacentes glissantes $m = m_{\mathrm{p}}$=m_{f} et leurs pas de progression Δ_n. On confirme, que les valeurs de $m = 1.5$s et $\Delta_n = 0.2$s sont des réglages adéquats au regard de la l'erreur obtenue (10.73%).

fichier	RVG-BIC		KCD	
	FA	DM	FA	DM
$bndz1$ (15 pts)	8	4	9	2
$bndz2$ (19 pts)	8	5	7	2
$bndz3$ (21 pts)	10	7	11	4
$bndz4$ (35 pts)	18	8	17	5
$bndz5$ (39 pts)	12	9	14	5
$bndz6$ (42 pts)	15	8	13	5

Table 1: Expériences sur signaux composites

fichier	RVG-BIC		KCD	
	FA	DM	FA	DM
$file1$(55pts)	10	9	11	4
$file2$ (63pts)	9	12	12	5
$file3$(59 pts)	12	15	16	4
$file4$(62 pts)	10	8	9	4

Table 2: Expériences pour Interventions courtes

Evaluations de stratégies de paramétrisation acoustique

Nous présentons dans cette sous-section l'impact des diverses stratégies de paramétrisation acoustiques décrites dans la table 6. Le but poursuivi est d'évaluer l'effet de combinaison des descripteurs sur les performances de notre méthode. Cette combinaison est réalisée en concaténant plusieurs vecteurs acoustiques résultant de diverses paramétrisations.

Pour chaque configuration, nous avons optimisé la sélection des paramètres, telle que mentionnée dans la section ci-dessous. Nous reportons dans les tables 7 et 8 les erreurs minimales obtenues avec le jeu de paramètres sélectionné.

L'estimation du nombre de locuteurs présents dans la conversation analysée est obtenue en parcourant le dendrogramme selon une coupe horizontale, ce qui revient à faire une hypothèse sur le nombre de locuteurs désiré puis de vérifier celle-ci selon la performance obtenue. Les travaux de synthèse reportés dans [9] offrent une explication claire sur la détermination automatique du nombre de locuteurs. Nous observons que les résultats confirment que la combinaison de diverses paramétrisations acoustiques (C_1, C_2 et C_5) améliorent globalement les résultats pour les deux méthodes avec une nette supériorité pour la méthode KCD. Ce résultat confirme aussi les conclusions portées dans les travaux [7] et [2] à savoir qu'une paramétrisation conjointe peut mettre en évidence des caractéristques du signal de parole qui peuvent être cachées en utilisant une paramétrisation unique.

4.5 Validation sur les fichiers d'évaluation

La table 9 montre que notre méthode obtient des taux d'erreurs DER bien inférieurs à la méthode de référence RVG-BIC. Le meilleur résultat obtenu est la moyenne sur ces trois fichiers, soit un taux d'erreur de 11.30%. Ces résultats sont d'autant plus prometteurs car comparés à ceux publiés récemment dans la littérature constituant l'état de l'art [9] et [14] dans laquelle les méthodes présentées ont été optimisées indépendamment de notre algorithme.

5 CONCLUSIONS ET PERSPECTIVES

Les résultats présentés dans cette étude montrent clairement que notre approche basée sur un algorithme à base des méthodes à vecteurs support mono-classe ouvre une voie de recherche très prometteuse pour l'indexation en locuteurs de discours multi-locuteurs. Nous avons montré comment intégrer la mesure de similarité basée sur le modèle des SVM mono-classe pour des tâches de détection de ruptures et de regroupement en locuteurs. Un autre résultat intéressant concerne l'étude comparée des méthodes RVG-BIC et SVM-1 en fonction des diverses stratégies de paramétrisation. Ainsi, il apparaît, qu'une paramétrisation même redondante améliore les résultats globalement pour les deux méthodes mais que c'est notre méthode qui assure une nette supériorité. Un travail en cours concerne la sélection des descripteurs acoustiques selon les performances obtenues par le modèle SVM-1 en faisant varier ses paramètres (m_{p}, m_{f} et σ). Une autre perspective intéressante est l'automatisation de la sélection du seuil de détection qui reste un problème ouvert pour les méthodes RVG-BIC et KCD.

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σ	DER
1.29	33.12
1	43.78
0.85	12.57
0.75	21.01
0.707	13.60
0.67	14.88
0.62	16.41
0.58	15.75
0.54	12.87
0.51	10.73
0.49	12.46
0.45	23.86

Table 3: Evolution du DER (%) en fonction de σ

m (s)	0.5	0.7	0.9	1.5	2.5	3.5
DER (%)	14.70	13.83	12.71	10.73	16.65	25.36

Table 4: Evolution du DER en fonction de la taille des fenêtres glissantes m pour ν=0.1s, σ=0.51 et $\Delta_n = 0.2$s

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Δ_n (s)	0.1	0.2	0.3	0.4	0.5	0.6
DER (%)	24.42	10.73	11.93	15.27	12.85	22.68

Table 5: Evolution du DER en fonction du pas de progression Δ_n, pour $m = 1.5$s, $\nu = 0.1$ et $\sigma = 0.51$

Configuration	composition du vecteur acoustique
C_0	16 MFCCs
C_1	16 MFCCs et 10 LPCCs
C_2	C_1 et 10 coefficients de reflection
C_3	C_2 et 10 coefficients banc de filtre
C_4	16 MFCCs et 16 ΔMFCCs
C_5	C_4 et 16 $\Delta\Delta$MFCCs

Table 6: Paramétrisations acoustiques testées.

Config	DERmin (%)		estim. # loc.	
	KCD	RVG-BIC	KCD	RVG-BIC
C_0	10.73	26.38	17	9
C_1	8.37	21.18	17	9
C_2	7.95	15.08	17	11
C_3	10.90	15.26	9	9
C_4	11.44	20.91	13	11
C_5	8.63	14.30	19	11

Table 7: Performances comparées (KCD/RVG) en fonction des paramétrisations acoustiques décrites dans Table 6.

Configuration	Jeu de paramètres selectionné
C_0	$m = 1.5$s,$\sigma = 0.51$, $\Delta_n = 0.2$s.
C_1	$m = 2.0$s,$\sigma = 1$, $\Delta_n = 0.3$s
C_2	$m = 1.5$s,$\sigma = 1$, $\Delta_n = 0.3$s
C_3	$m = 2.5$s,$\sigma = 0.707$, $\Delta_n = 0.2$s
C_4	$m = 0.7$s,$\sigma = 0.707$, $\Delta_n = 0.2$s
C_5	$m = 0.9$s,$\sigma = 0.85$, $\Delta_n = 0.3$s

Table 8: Jeu de paramètres en fonction des paramétrisations acoustiques testes.

Fichier	RVG-BIC	KCD	Estimation du Nbre de Locuteurs
(a)	25.60	11.25	21
(b)	20.17	10.55	20
(c)	22.69	12.11	28

Table 9: Résultats obtenus sur les signaux d'évaluation. Les paramètres sont $m = 1.5$s, $\nu = 0.1$, $\sigma = 0.51$ et $\Delta_n = 0.2$s. La paramétrisation choisie est C_2. Les fichiers sont (a) 20010228.2100-2200-MNB-NBW, (b) 20010217.1000-1030-VOA-ENG and (c) 20010220.2000-2100-PRI-TWD.

Estimating Torpedo Range using Multi-path Signals and Fast Orthogonal Search Techniques

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ABSTRACT

This paper introduces a torpedo range estimation algorithm, which is primarily developed in MATLAB. The Torpedo Detection Algorithm (TDA) employs the fast orthogonal search (FOS) algorithm for high-resolution spectral analysis to detect the closely spaced direct-path and surface-reflection signals. When a direct-path and surface-reflection are found, an automatic alert of a possible torpedo detection is initiated. In simulation, the existence of a torpedo and its range are found as it travels from 5000 to 750 metres from the receiver. Simple trigonometric expressions are used to estimate the torpedo's range given the two frequencies estimated by FOS and a priori information about the torpedo speed and depth. The predicted and actual ranges for a simulation in which a torpedo approaches from 5000 to 750 metres is shown.

SOMMAIRE

Cet article présente un algorithme d'estimation de la portée d'une torpille qui a été principalement développé à l'aide de MATLAB. L'algorithme de détection de torpille (ADT) utilise l'algorithme de recherche orthogonale rapide FOS qui permet une l'analyse spectrale de haute résolution pour détecter les signaux adjacents provenant des retours de signaux directs et des réflexions de surfaces. Lorsqu'un signal direct et un signal réfléchi sont décelés, une alerte automatique est déclenchée pour indiquer la détection possible d'une torpille. Par simulation, l'existence d'une torpille et sa portée sont évaluées pour un rayon d'opération variant de 5000 à 750 mètres du récepteur. Des expressions trigonométriques simples sont utilisées pour estimer la portée de la torpille en se basant sur les deux fréquences estimées par l'algorithme FOS et sur de l'information connue au préalable sur la vitesse et la profondeur de la torpille. L'article présente les portées prédites et exactes obtenues par simulation pour une torpille s'approchant de 5000 à 750 mètres.

I. INTRODUCTION

In a busy acoustic environment, torpedo detection from an operator perspective is very challenging, as the operator must manually search for visual cues to make a torpedo assessment. These cues are presented visually based on Fourier series analysis. Not only is the acoustic picture complicated by environmental factors and multiple sources from multiple platforms, a torpedo signal may initially be very weak and not identified at its earliest detection by an acoustic operator. Based on the short timeframe to impact of a high-speed torpedo, early detection by an operator is critical in order to allow sufficient time for a warship to effectively react. An automated system could alert operators at the earliest stage.

When a torpedo approaches a passive sensor at a constant bearing (zero bearing rate), the speed and range of the torpedo cannot be estimated using conventional techniques [1,2]. The precise source frequency of the torpedo may not be known, so the Doppler shift of the torpedo is also unknown and cannot be used to estimate the speed. Also the magnitude of the signal at the source as well as the acoustic path attenuation is unknown, so the range of the torpedo cannot be easily estimated.

For a submerged target, such as a torpedo, the acoustic detector will receive a direct-path signal, a signal reflected off the surface as well as other multi-path components [1]. The direct-path and surface-reflected signals will have slightly different Doppler shifts due to the different angles of arrival. The direct-path and surface-reflected signals will be very close in frequency even for a high-speed target such as a torpedo. For surface ships and slow submerged targets, the difference in frequency of the direct-path and surface-reflection signals is typically too small to detect outside 1000 m. Thus the presence of two closely spaced frequency components can be used to indicate the presence of a torpedo. The Torpedo Detection Algorithm (TDA) employs the fast orthogonal search (FOS) algorithm to detect the closely spaced direct-path and surface-reflection signals. The direct-path and surface-reflected signals are so close in frequency that they are difficult to resolve using an FFT. The FOS algorithm has been shown to have up to 10 times the frequency resolution of the FFT for the same length of data [3,4]. Thus, the FOS algorithm is used to perform a high-resolution spectral analysis of the passive acoustic data. If two closely-spaced frequencies are resolved by FOS, then TDA indicates the presence of a torpedo.

In addition to the FOS algorithm used in the TDA, a number of other techniques including multiple-signal classification (MUSIC), canonical variate analysis (CVA) and modified covariance auto-regression (MODCOVAR) have been shown to give a spectral estimate with higher resolution than the FFT. The FOS algorithm has been found to correctly identify closely spaced harmonics more frequently than the root-MUSIC algorithm [5, 6] and the MODCOVAR algorithm [7]. The FOS algorithm was also compared against CVA for modeling nonlinear auto regressive processes and the FOS method was found to generate a model using fewer model terms. [7]. Thus in the TDA the FOS algorithm was chosen for high-resolution spectral analysis.

The frequency separation of the direct-path and surface-reflected signals can be used to estimate a torpedo's range given the depth of the receiver and speed and depth of the torpedo.

The received time series from a torpedo approaching a detector was simulated using the WATTCH [9] model. In this simulation, a single receiver was used, although this technique could be used for a towed array receiver along a single beam. The TDA was used to notify of possible detections and estimate torpedo range, which was then compared to the actual torpedo range from the simulation.

2.0 DOPPLER SHIFT

Consider a submerged target approaching an acoustic receiver as shown in Figures 1 and 2. There will be a direct-path signal between the target and receiver as shown in plan view (Figure 1).

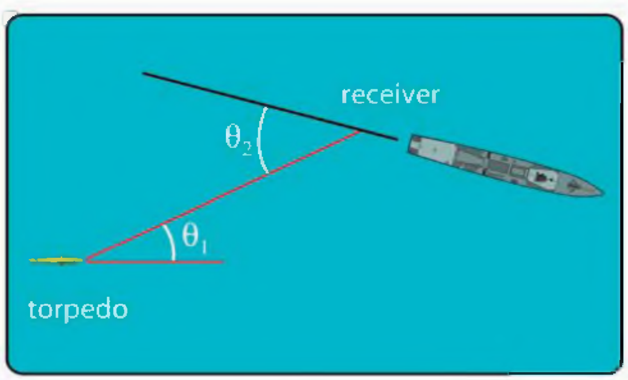

Figure 1 The top view as a target approaches a receiver.

The signal at the receiver will be Doppler shifted according to [1]

$$f_d = \frac{f_0 (c - v_s \cos\theta_2)}{(c - v_t \cos\theta_1)} \qquad (1)$$

where f_0 is the frequency of the target, v_s is the speed of the receiver, v_t is the speed of the target, θ_1 is the angle between the target direction and the receiver, θ_2 is the angle between the receiver and the incoming direct path signal, and c is the sound speed.

The signal arrival has a horizontal component (Figure 1) and a vertical component (Figure 2). When both components are accounted for, the Doppler shift associated with either the direct path (i=1) or surface-reflected path (i=2) is given by

$$f_d = \frac{f_0 (c - v_s \cos\theta_2 \cos\phi_i)}{(c - v_t \cos\theta_1 \cos\phi_i)} \qquad (2)$$

where ϕ_i is the angle between the receiver and the arriving ray. For the purposes of the remainder of this paper, the target is assumed to be directly approaching the receiver at constant depth equal to the receiver depth (θ_1 = 0, ϕ_1= 0). The assumptions of constant bearing and depth are likely to stand at least approximately for the chosen set of ranges in a realistic situation. The assumption that the torpedo is at the same depth as the receiver will depend on the exact threat and the response to it, i.e. a deep-running threat will require a deep receiver.

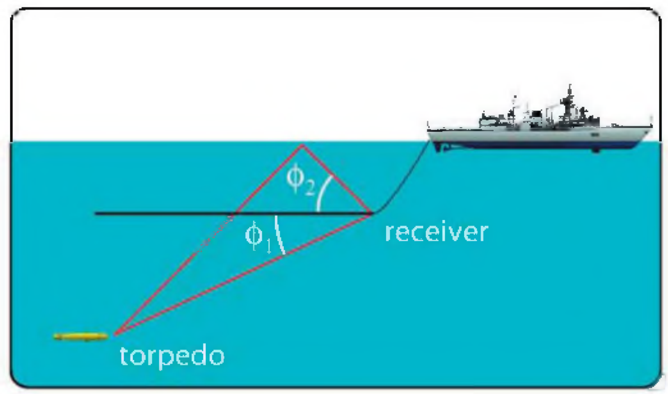

Figure 2 The direct-path and surface reflection path as a target approaches a receiver.

Figure 3 shows the frequency separation between the direct-path and surface-reflected signals for a 500 Hz sinusoidal signal at the target. The frequency separation is calculated using equation (2). The earliest torpedo detection assessment that can be made by the FFT and the TDA based on empirical testing are also shown in Figure 3. The spectral resolution of FOS is signal dependent [3,4]. So although FOS has been shown to have up to 10 times the frequency resolution of the FFT at a given sampling rate (for sufficiently high signal-to-noise ratio, see e.g. [8]), 8 times the frequency resolution was used in this work, as indicated by the line marked TDA in Figure 3. The sampling rate used was 4096 Hz. At FOS resolutions above 8, the algorithm is unreliable and takes much longer to process. With the TDA resolution, torpedoes can be detected with confidence from approximately 2400 m from the detector based on the acoustic sensor receiving the initial torpedo signal at approximately 5000 m. If the FFT was employed in the algorithm to detect the direct-path and reflected path signals, a signal cannot be accurately assessed as a torpedo until approximately 1000 meters as shown in Figure 3. The FFT does not have the necessary resolution to separate the signals at longer range.

3.0 DETECTION ALGORITHM

The TDA detects incoming torpedoes by using an iterative FOS algorithm call FOS-first-term-reselection (FOS-FTR [4]) to detect both the direct-path and surface-reflected signal from a torpedo. Since FOS is a relatively slow algorithm, the FFT is used on the raw signal to localize the energy in the signal. Then FOS is employed in a very narrow band around the peaks in the FFT to try to detect two closely space signals. If two closely spaced signals are detected, then a torpedo is considered present. It should be noted here that a decision of signal presence for both frequency components is required to proceed with the torpedo presence validation and range estimation. Therefore, the TDA is effectively screening out false targets using a standard FFT detector on the initial signal and then a FOS detector on the surface reflection signal – the false alarm rate should be the product of the rates of these two detectors. Next, using trigonometric relations and the speed and depth of the target (assuming that it is known a priori, an assumption based on reliable intelligence for a given threat and target type) the range to the target can be estimated. The procedure can then be repeated using an overlapping sliding time window to decrease the time between executions of the detection algorithm.

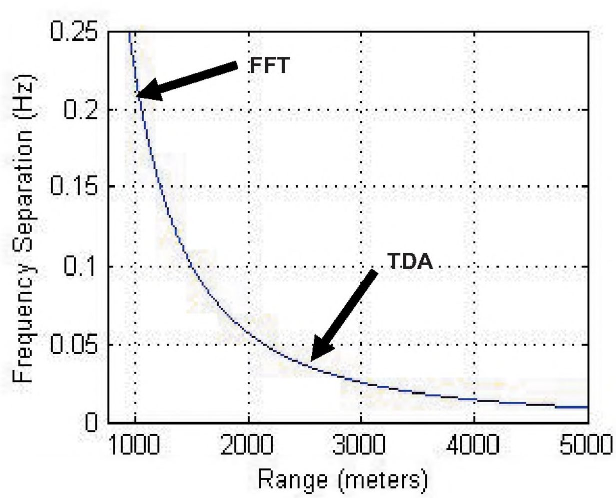

Figure 3 The frequency separation of the direct-path and surface reflection for a 500 Hz signal between a range of 5000 and 750 m. Based on the frequency resolution of the FFT and TDA, the earliest accurate torpedo detection assessments are indicated by the arrows. The target and receiver are at 100 m. depth.

4.0 SIMULATION RESULTS

The time series resulting from a torpedo approaching a receiver was simulated using the WATTCH [9] model. WATTCH uses the US Naval Underwater Weapons Center (NUWC) Generic Sonar Model (GSM) [10] to provide frequency-dependant eigenrays as input. The GSM input environment was based on an August North Atlantic (42°N 54°W) sound speed profile [11]. Figure 4 shows the deep-water profile. In simulating the environment, the Thorp volume attenuation model and Bechmann-Spezzichino surface reflection model were assumed. Seabed effects were included by assuming a reflection loss coefficient and Rayleigh phase-shift model based on seabed with a 1650 m/s sound speed and 1.9 g/cm^3 density. Isotropic noise was added with a spectrum given by the Wenz ambient noise model, with shipping level 4 was assumed. The wind speed and wave height were assumed to be 8 knots and 1.5 m, respectively. This results in noise levels of 108 dB re 1 μPa at 1 Hz, 78 dB re 1 μPa at 10 Hz, and 67 dB re 1 μPa at 500 Hz.

WATTCH simulated the received time series based on a torpedo with a 500 Hz tone with source level of 160 dB re 1 μPa at 1 m (about 20 dB SNR at 5000 m). Strong 60 Hz and 400 Hz (sound pressure levels of 100 and 80 dB re 1 μPa at the receiver, respectively) interfering tonal signals were added to simulate the presence of mechanical noise. The WATTCH simulation was based on the torpedo closing on the receiver with a speed in excess of 25 m/s with both torpedo and receiver having a depth of 100 m. The receiver is assumed to be stationary.

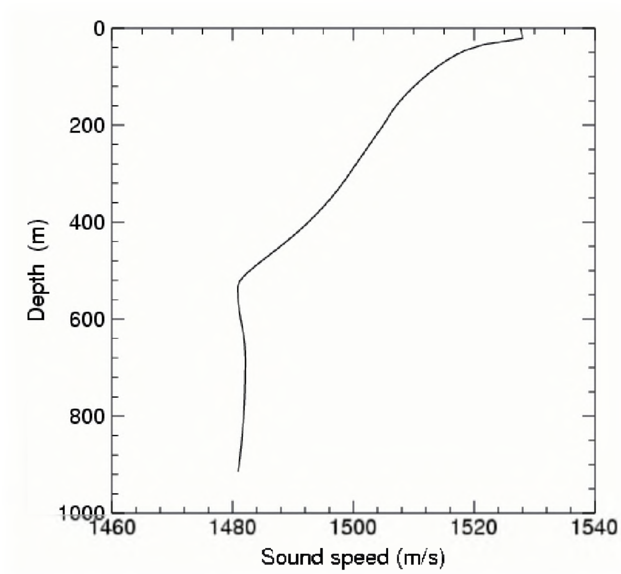

Figure 4 Podeszwa [7] North Atlantic Sound Speed Profile.

Figure 5 shows the frequency separation of a torpedo detected by the FOS-FTR algorithm using 20 iterations of the FOS algorithm (corresponding to different ranges) as the torpedo approached the receiver. The record length varied over the duration of the signal, starting at 80 s and was continually shortened as the torpedo approached the receiver so that the surface-reflected signal remained constant in the record length. The presence of a non-zero frequency separation, as illustrated in Figure 5, indicates the presence of a torpedo. Since two closely spaced frequencies were detected at each iteration, the TDA correctly assessed a torpedo for this single realization in 20 of the 20 iterations shown.

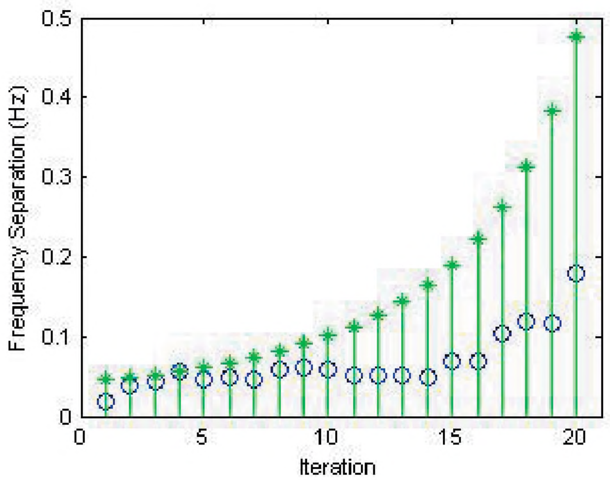

Figure 5 The frequency separation found by the FOS-FTR algorithm for 20 iterations (circles) as the torpedo closed on the receiver from 5000 to 750 m. The theoretical frequency separation is shown by asterisks (*).

Figure 6 shows the predicted range and the actual range of the torpedo as it approaches the receiver. Note that the predicted range has an average absolute error of 450 m over the set of iterations, or approximately 36% as an average percentage error over the 20 range iterations, and appears to predict a greater range than the true value in nearly all of the 20 torpedo evaluations. The percentage error seems to decrease with decreasing range to a point, and then to increase. It seems counter-intuitive that with increasing signal to noise ratio and frequency separation in the final iterations the error would increase. It is possible that the algorithm or the simulation suffers from a degree of "lag", i.e. that the range estimate is including some information from earlier separations.

5.0 Conclusion

Based on the simulation presented, a proof of concept of torpedo detection and localization using the FOS-FTR algorithm has been demonstrated. Given detailed intelligence about the torpedo's speed and depth, the range can be calculated within 950 m, with an average error of 450 m. Further investigations to improve range estimation are ongoing.

6.0 Acknowledgement

The WATTCH model was developed at DRDC Atlantic with support from the US Office of Naval Research.

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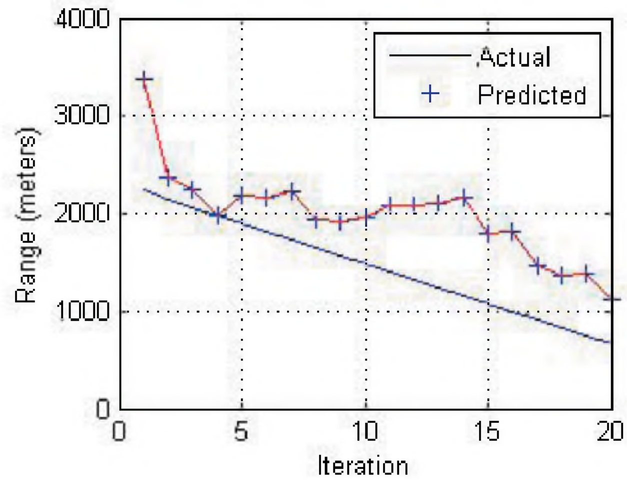

Figure 6 The predicted range (+) and actual range as a torpedo approaches a receiver.

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Methods For Mitigating The Vigilance Decrement In An Auditory Sonar Monitoring Task: A Research Synthesis

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ABSTRACT

Sustained attention or operator vigilance is required in the detection of critical signals that occur infrequently and at irregular intervals over a prolonged period. In this paper, we review some methods for mitigating the vigilance decrement for an auditory sonar monitoring task. These methods pertain to enhancing the saliency of sonar targets for situations when the operator may be required to monitor multiple displays, listen to competing sound sources, attend to distractions, and cope with ambient noise. Enhanced target saliency is expected to assist in maintaining operator efficiency via increasing detection rate and decreasing detection latency of auditory sonar targets. This should lead to tactical superiority of sonar operators in the continuing threat of underwater warfare.

SOMMAIRE

Il est nécessaire que l'opérateur fasse preuve d'une attention ou d'une vigilance soutenues pour détecter les signaux critiques qui se produisent peu fréquemment et à des intervalles irréguliers sur une période prolongée. Le présent document examine certaines des méthodes permettant d'atténuer la baisse de vigilance durant une tâche auditive de surveillance sonar. Ces méthodes mettent en évidence des cibles sonar dans des situations où l'opérateur doit surveiller plusieurs affichages et prêter l'oreille à des sources sonores conflictuelles alors qu'il est exposé à des distractions et à du bruit ambiant. La mise en évidence des cibles devrait aider à maintenir l'efficacité de l'opérateur en augmentant le taux de détection et en diminuant la latence de détection des cibles sonar durant une tâche auditive. Il devrait en résulter une supériorité tactique de l'opérateur sonar dans la menace permanente de la guerre sous-marine.

1. INTRODUCTION

Submarine warfare continues to pose a threat in present-day military operations. This prompted the Canadian Forces (CF) to research and develop sonar systems in an effort to increase the probability of enemy detection (Theriault & Chapman, 2001). Despite the ongoing technological improvements made to sonar systems, the human operator remains as an integral component in sonar watchkeeping. To this end, we initiated a research project within Defence R&D Canada (DRDC) – Toronto to investigate techniques for maintaining operator vigilance or sustained attention. Our synthesis of the literature on vigilance forms the basis of the present paper.

Operator vigilance is required in the detection of critical signals that occur infrequently and at irregular intervals over an extended period of time (e.g., detecting targets in military surveillance devices, airport security inspection of x-rayed carry-on luggage, industrial inspection of products, and monitoring of automated systems).

Undoubtedly, the failure to detect targets for real-world applications could have severe consequences. The laboratory study of vigilance, dating back to World War II, was prompted by the British military's need to understand the decline in performance of airborne radar operators engaged in antisubmarine warfare who missed blips on the plan position indicator radar screen after only about 30 minutes on watch. N.H. Mackworth (1950) was commissioned by the Royal Air Force in 1948 to address the observed decline in radar operator performance. He devised the "Clock Test" which consists of a single rotating black pointer on a white background. The pointer moved clockwise to the next position once every second. Occasionally, however, the pointer "jumped" twice the normal distance. The "double jump" of the pointer was the target, and the participant's task was to indicate when he/she detected its occurrence. Twelve targets had to be detected per 30 minute period of the 2-hour watch, appearing at intervals from 45 seconds to 10 minutes. Detection efficiency, as measured by number of missed targets, deteriorated rapidly after the first 30 minutes which confirmed the results of the analysis of detections from real radar operations. The failure to detect targets is not restricted to the visual modality. In a separate experiment, Mackworth (1950) found that the incidents of missed targets for an auditory task also increased as a function of time on task.

Following Mackworth's (1950) pioneering studies, investigations on factors that affect operator attentiveness for the detection of critical signals have been conducted using a myriad of experimental paradigms and performance measures (for reviews see Ballard, 1996; Davies & Parasuraman, 1982; See, Howe, Warm, & Dember, 1995; Warm, 1984, 1993). The results of these studies have generally confirmed Mackworth's observation of a decline in observer performance (called the "vigilance decrement") over time (referred to as the "watch"). A view held for many years was that the decrement could be attributed to signal detection theory (SDT) measures of the user's sensitivity (d′) and the user's own criterion (β) (Green & Swets, 1966; Macmillan & Creelman, 1991) whereby a drop in arousal can cause a decrease in d' as to the presence of the target or a shift in β (more or less conservative criterion) as to what sensory inputs constitute a target (Davies & Parasuraman, 1982; Warm, 1984). However, recent evidence suggests the alternative explanation that the information processing demand of a vigilance task is high and the decrement reflects the depletion of information-processing resources over time (Helton et al., 2005; Johnson & Proctor, 2004; Warm & Dember, 1998; Warm, Dember, & Hancock, 1996). Warm et al. (1996), for example, found that ratings of mental demand increased linearly over the course of the vigil as measured by the NASA-TLX index – an instrument used to measure perceived mental workload on the processing resources imposed by a task (Hart & Staveland, 1988).

The results of laboratory studies on vigilance research have shown that techniques can be applied to mitigate the vigilance decrement (e.g., Baker, 1962; Jerison, 1967; Schmidke, 1976). The validity of these results depends upon the successful transfer of laboratory results to real-world applications. To date, there are only a few published studies relating to the application of laboratory research findings for maintaining operator performance or efficiency in real-world tasks. Investigators have observed a decline in vigilance in tasks such as detection of aircraft entering designated air space (Pigeau, Angus, O'Neill, & Mack, 1995), monitoring sonar signals (Colquhoun, 1967, 1975, 1977), and keeping watch for automation failure in a flight simulation task (Molloy & Parasuraman, 1996). The decrease in operator performance noted in operational tasks requires that techniques be developed for maintaining alertness. One method that has been shown to maintain or improve user efficiency is an increase in the saliency of the target (Colquhoun, 1967; Lisper, Kjellberg, & Melin, 1972). Weak targets, such as those found in a real-world sonar environment, may go undetected by the operator. This may compromise tactical superiority in submarine warfare (Arrabito, Cooke, & McFadden, 2005). Enhancing the saliency of targets is expected to make more targets perceptible to the operator. This should lead to maintained or enhanced performance as reflected by an increase in detection rate, a decrease in the number of false alarms and incidents of missed targets, and a faster response time to targets that are correctly detected. The objective of the present paper is to discuss methods for enhancing the saliency of aural sonar targets.

2. THE SONAR ENVIRONMENT

The sonar operator, either on board an aircraft (fixed or rotary wing) or a vessel (surface ship or submarine), is responsible for accurately detecting the presence and determining the position of targets (e.g., surface ships, submarines, torpedoes, and mines) to allow for effective weapon deployment. Sounds received at the hydrophone (an underwater microphone) of the sonar systems are initially processed to help make the signals perceptible to the human observer, and these data are presented on a visual and/or auditory display (Urick, 1983). Aural signals are usually presented over headphones, especially in a noisy environment (e.g., in aircraft or in the Operations room of a vessel containing multiple sonar consoles). The operator must monitor the display and report when he/she detects the target. The acoustic characteristics of targets are generally unknown because recordings of sonar signals are typically produced by military organizations and often these become classified. Operators evaluate the aural characteristics of sonar sounds within a frame of reference or vocabulary (e.g., "heavy", "light", "bright", "dull", "hard", and "soft") and judge them as either a target or non-target (Collier, 2004; Solomon, 1958). In practice, the operator attempts to get multiple readings on an object over time in an effort to ensure high accuracy. Data on sonar detection performance is not available. Once a target is detected, the operator will determine its position and attempt to classify and track the source. The watchstanding period is typically between 2-3 hours on helicopters, 4-8 hours on fixed wing aircraft, and 8-12 hours on vessels (Arrabito et al., 2005). Rest periods are given when possible, and are often dictated by operational requirements.

Sonar systems can generally be categorized as passive (listening) or active (echo ranging). A passive sonar system is designed to detect the noise radiated by a target and received at the hydrophone(s). An active sonar system emits a short duration acoustic pulse that is propagated in the water towards the desired target. There are two broad classes of pulses: coherent and incoherent sources (Le Méhauté & Wang, 1996; Urick, 1983). The choice of pulse type is application specific (Horton, 1957; Le Méhauté & Wang, 1996; Waite, 2002). The returned signal from the pulse received at the hydrophone array contains one or more echoes. The echo is the acoustic energy that is reflected from the target. The echo is only a fraction of the acoustic energy of the transmitted pulse and can often be obscured by reverberation which is the acoustic energy reflected from sources other than the desired target. The received echo is the bearing (i.e., co-ordinates) of the target. The range (i.e., distance) of the target is calculated by taking into account the non-homogeneity of the ocean environment (due to the water varying in density, temperature, and salinity that can distort the sound), and the time between the offset of the transmitted pulse and the reception of the echo. The hydrophones are generally configured in an array (examples of array types include a line, broadside, shaded, planar, cylindrical, conformal, spherical, and volumetric (Waite, 2002)) in order to improve the signal-to-noise ratio (SNR) of the source against a noise background. Some examples of sonar systems are shown in Figure 1. The choice of sonar system is a function of the current tactics.

Having superior sonar equipment is by no means a suf-

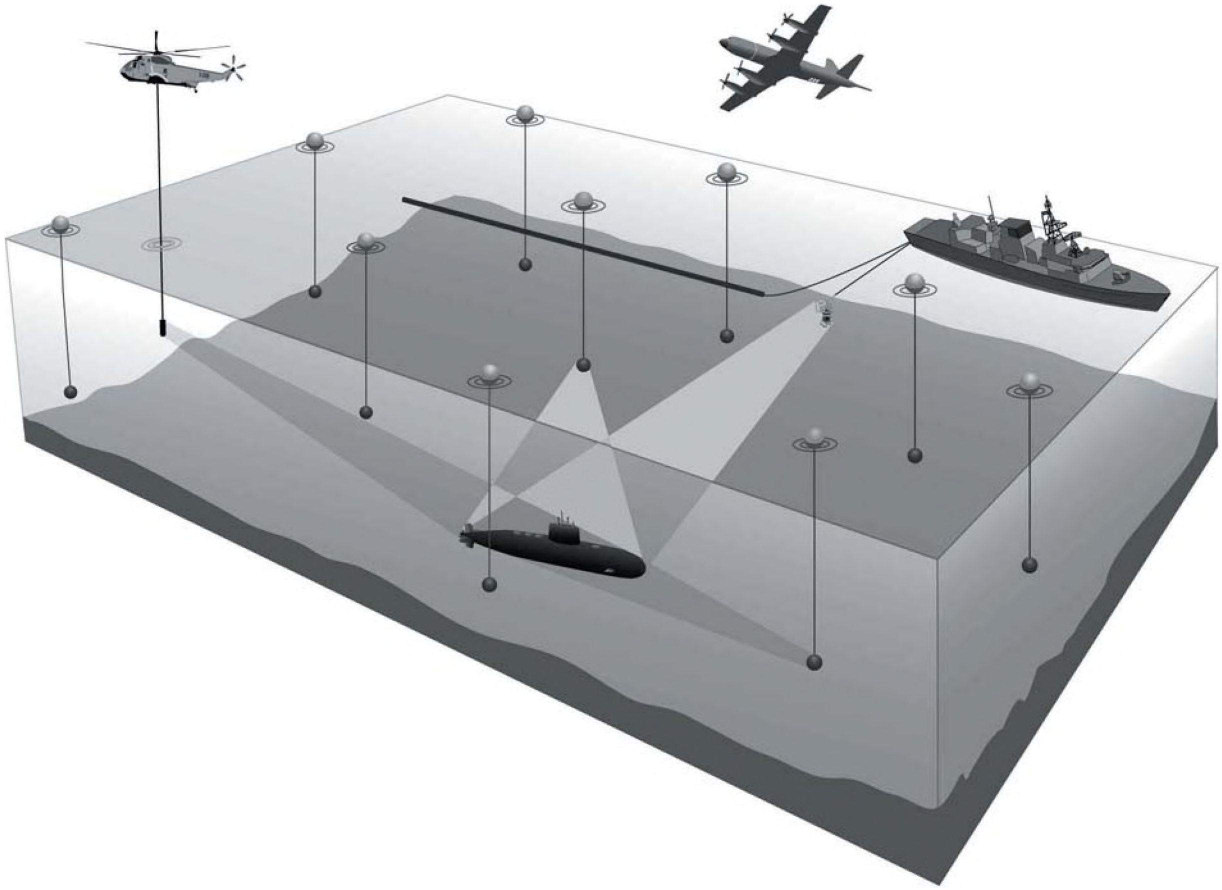

Figure 1: Some examples of sonar systems. The surface ship is towing two different arrays, a long passive array and an active multistatic array. The airplane has deployed ten sonabuoys (often shortened to "buoys") in a predefined pattern; each buoy has a hydrophone and a radio transmitter. Data from the buoys are radioed to the aircraft for processing, and displayed to the operator for interpretation. A dipping sonar system is employed by the helicopter. Although not illustrated in this figure, a vessel (surface ship or submarine) could also employ a hull-mounted sonar system which is located on the hull of the vessel (usually on the keel). The figure illustrates how the different sonar systems can be used to detect an underwater or surface target. Courtesy of Neil Sponagle, Defence R&D Canada – Atlantic.

ficient condition for achieving success in a mission. Often many factors can influence the performance of the sonar operator in the task of detecting and classifying targets. These include sound travel in water (e.g., foreign objects, absorption, scattering, reflection, and reverberation), environmental factors (e.g., time of day, weather, season, ambient noise, water depth, and salinity), own ship performance (e.g., ship and sonar design, speed, and self noise), target strength (e.g., target design, signature and speed), and operator conditions (e.g., doctrinal practices, operator experience and intuition, motivation and alertness) (Cox, 1974; Horton, 1957; Moore & Compton-Hall, 1986; Urick, 1982). The variability of the tactical environment contributes to the difficulty of detecting and classifying targets (Cox, 1974; Moore & Compton-Hall, 1986). Once the target is detected and classified, a variety of weapons (e.g., missile, torpedo, and mine) could be deployed (Moore & Compton-Hall, 1986). Targets in turn can utilize countermeasures, such as maneuvering or deploying devices, to reduce the success of an attack (Cox, 1974; Moore & Compton-Hall, 1986).

3. SOME METHODS FOR COMBATING THE VIGILANCE DECREMENT

The application of SDT (Green & Swets, 1966; Macmillan & Creelman, 1991) to the analyses of vigilance tasks was first proposed by Egan, Greenberg, and Schulman (1961). This represented a major advance in the assessment of user efficiency. SDT takes into account false alarm rates which were not done in early studies of vigilance. In this section, we list some countermeasures for altering d' (by manipulating sensory parameters), and β (by manipulating nonsensory parameters) that could help attenuate the decrement for an auditory sonar monitoring task. For a more detailed discussion of these countermeasures, the reader is referred to Davies and Parasuraman (1982), and Matthews, Davies, Westerman, & Stammers (2000). We note that these techniques have been explored in controlled laboratory experiments and thus their applicability to operational scenarios has yet to be determined.

3.1. Techniques to Increase d'

- Decrease the event rate (i.e., rate of presentation of non-targets) (Jerison & Picket, 1964; Loeb & Binford, 1968). In an operational setting, unwanted events are usually more frequent than targets. Jerison and Picket (1964) were the first to show that an increase in event rate for a visual vigilance task lead to a decrease in detection rate and an increase in missed targets.
- Increase the probability of target occurrence (i.e., the ratio of target to non-targets) (Colquhoun, 1961). In a visual vigilance task, Colquhoun (1961) varied signal frequency and target probability independently. He found that an increase in target probability improved detection efficiency but a similar increase in signal frequency produced no significant alteration in detection efficiency.
- Enhance the saliency of the target (e.g., by prolonging the duration or increasing the intensity) relative to non-targets (Colquhoun, 1967; Lisper et al., 1972). The detection of stimuli is positively related to increases in signal saliency. Lisper et al. (1972) investigated the effect of signal intensity response time on an auditory monitoring task. Participants were instructed to respond as quickly as possible when they heard the target which was presented at four different signal intensities. The results showed that speed and accuracy increased as a function of increasing signal intensity.
- Give the user extensive practice (Colquhoun, 1975; Colquhoun & Baddeley, 1967). Colquhoun and Baddeley (1967) varied signal probability during pretraining in an auditory vigilance task. The authors found that practice increased overall number of signals detected but that higher signal probability lead to an increase in false alarms.
- Inject artificial signals that closely resemble the target (Mackie, Wylie, & Smith, 1994). Mackie et al. (1994) observed enhanced operator vigilance when signal injection was provided in a task that required participants to detect passive sonar targets presented on a visual display. Enhanced operator performance was reflected by increased target detection and decreased latency times in the detection of the targets.
- Present varied noise at a low sound level provided that the vigilance task is not complex (Hancock, 1984; Matthews et al., 2000; Nachreiner & Hanecke, 1992). Such results are dependent in part upon task difficulty, the state of the individual, and the ability of the individual to learn how to perform the task in quiet and in a background of noise.

3.2. Techniques to Optimize β

- Instructions favoring risk in responding to the presence of the target (Colquhoun, 1967). Colquhoun (1967) used a simulated auditory sonar task in which participants were instructed to adopt two strategies for determining the occurrence of a target. In four of the eight sessions, participants were instructed to report the presence of the target when they were absolutely certain they had detected the target ("sure condition). In the other four sessions participants were instructed to report any target-like signal ("unsure" condition). There was a substantially a higher percentage of signals detected in the "unsure" condition than in the "sure" condition.
- Provide the user with performance feedback or knowledge of results (Mackworth, 1950; Wiener, 1963). Performance efficiency can be substantially improved by providing feedback or knowledge of results (KR) to the observer. Wiener (1962) investigated varying levels of KR in a visual monitoring task. He found that mean probability of detection increased as a function of increasing KR. False alarms were higher with partial KR than with either full KR or no KR.
- Include periodic breaks throughout time on task (Davies & Parasuraman, 1982; Mackworth, 1950). Rest periods or assigning another activity can have beneficial effects on monitoring performance. Mackworth (1950) recommended that the break should occur within the first 30 minutes of the watch.
- Employ methods to motivate the user (e.g., participants' knowledge of the presence of the experimenter in the test facility, and periodic encouragement) (Fraser, 1953; Mackworth, 1950). Fraser (1953) used a modified version of Mackworth's (1950) clock test. Participants were tested with and without the presence of the experimenter in the laboratory. Fraser (1953) found that the presence of the experimenter improved performance.

4. THE SONAR VIGILANCE TASK

Monitoring for the appearance of critical signals is generally categorized as either a successive discrimination or a simultaneous discrimination vigilance task. Of these two paradigms, the monitoring for sonar targets could be classified as a successive discrimination task. In a successive discrimination task, the observer must remember the stimulus configuration of the target (i.e., signature of the sonar target) and subsequently compare the remembered signature against successively presented non-targets (e.g., a 2 dB increase in the intensity [target] of an intermittent 1000 Hz tone). In contrast, in a simultaneous vigilance task, the stimulus configuration of the target is present, and the observer has all the required information to make the discrimination between target and non-target (e.g., to detect a 1000 Hz tone [target] within an intermittent noise burst) (Parasuraman, 1979). Davies and Parasuraman (1982) have argued that a successive discrimination vigilance task is more capacity demanding than a simultaneous vigilance task. To test the validity of the taxonomy developed by Parasuraman and Davies (1977) for classifying task according to type of discrimination, See et al. (1995) conducted a meta-analysis of the sensitivity decrement based on 42 experiments published between 1980 and 1992 and confirmed that the sensitivity decrement in vigilance are linked to task differences. For example, increases in event rate had a more degrading effect on user performance for a successive than a simultaneous vigilance task (Lanzetta, Dember, Warm, & Berch, 1987).

In the context of an auditory sonar vigilance task, the decrement could arise from various factors that deplete the availability of information processing resources during the vigil. Generally, there is a low target rate (Mackworth, 1957) and long intervals of time (in the order of days or weeks) pass without a single target occurring (Mackie et al., 1994). The occurrence of critical signals at irregular intervals in time forces the observer to monitor the display continuously. This adds to task demand and has been shown to further degrade performance efficiency than when critical signals are presented at regular intervals. This effect is greater for a successive than a simultaneous discrimination vigilance task (Davies & Parasuraman, 1982; Helton et al., 2005; Warm & Jerison, 1984).

A smaller degradation in performance is expected in an auditory sonar watchkeeping task than its visual counterpart because the critical signals may be perceived aurally even when the operator's eyes are directed elsewhere (referred to as decoupling (Warm & Jerison, 1984)). Unlike an auditory display, the use of a visual display imposes postural constraint, and eye strain. To elucidate the differences across modalities, Szalma et al. (2004) equated auditory and visual vigilance tasks in discrimination difficulty and found that performance deteriorated with time-on-task, and that the auditory modality was superior to the visual modality; these results are in general agreement with previous findings (Davies & Parasuraman, 1982; Warm & Jerison, 1984). Szalma et al (2004) attributed the superiority of the auditory modality to the decoupling nature of visual displays which imposes task demand on a visual vigilance task (Galinsky, Rosa, Warm, & Dember, 1993).

Often the operator is unaware of the signature of a sonar target because targets may be camouflaged, muffled, or distorted due to the non-homogeneity of the ocean environment. Previous studies have shown that in instances where the target was not specified, participants had a lower percent correct and higher false alarm rate than when they were specified (Childs, 1976). Notwithstanding target specification, detection of sonar targets may be made more difficult if the level of the sound received by the hydrophone is too low relative to the level of the background noise (i.e., low SNR). The problem may be further exacerbated if the level of the target is close to the operator's threshold of audibility or if the target is a transient sound (e.g., hull popping that could be caused by a submarine changing depth, engine start-up sequences, and squeaks that could be caused by rudder motion). These factors relate to target saliency. We now propose some techniques to increase signal saliency which will decrease task difficulty (Davies & Parasuraman, 1982; Matthews et al., 2000).

5. METHODS FOR INCREASING SIGNAL SALIENCY FOR AN AUDITORY SONAR MONITORING TASK

Enhancing signal saliency, a technique used to increase sensitivity, was shown to mitigate the vigilance decrement for a simulated auditory sonar monitoring task (Colquhoun, 1967). In previous laboratory studies, the saliency of the target was enhanced simply by raising the intensity of the signal in relation to the background noise (Colquhoun, 1967; Lisper et al., 1972). However, this tactic may not always improve target detection because, for example, the overall sound level may become too loud, potentially leading to temporary or permanent hearing loss or interference with concomitant communication tasks. In this section we review some psychoacoustic methods for increasing the saliency of aural targets that could be applied to sonar watchkeeping, when the operator is required to monitor multiple displays, attend to distractions, and cope with ambient noise.

5.1. Sensory Modality

The probability of correctly detecting the target will be highest if the target is presented in the sensory modality best suited for eliciting the user's attention in the underlying monitoring task. Whilst a visual display may be effective for detecting narrowband sounds on passive sonar displays and for long range detection of targets, the visual modality is dependent of the direction of the operator's eyes and thus is not optimal for the detection of transient sounds. Transient sounds are difficult to disguise and can often alert the sonar operator to the presence of a target or signal a state change of the target being tracked. The aural presentation of these signals would lead to a greater probability of detection as the human auditory system excels in the detection of transient signals in the presence of noise (Moore, 1989). Sensory differences have also been found for visual and auditory vigilance tasks. The overall level of performance in auditory vigilance tasks tends to be greater than visual tasks, and the vigilance decrement is less pronounced in the auditory than in the visual modality (Davies & Parasuraman, 1982; Warm & Jerison, 1984; Szalma et al., 2004).

5.2. Competing Sound Sources

Competing sound sources could lower the probability of successful target detection. This is particularly difficult when the operator must detect the target in the presence of competing signals (e.g., speech). This is analogous to the "cocktail-party problem" (Cherry, 1953). Cherry (1953) investigated the listener's ability to focus his/her attention on a single sound source or signal in the presence of multiple competing signals and interfering noise. He suggested that the cocktail party problem could be solved primarily by spatially separating the sound sources. Spatial separation between signals for a sonar application could be realized over headphones via three-dimensional (3-D) auditory space (a technique to present sound over headphones that is convolved by means of a digital filter is perceived by the listener to emanate from outside his/her head at the location for which the digital filter was measured (Bronkhorst, 1995; Wightman & Kistler, 1989)). Ericson and McKinley (1997) investigated the viability of a 3-D audio display for solving the cocktail party effect. These authors reported improved speech intelligibility when more than two simultaneous talkers were each spatialized at unique positions in virtual auditory space compared to a diotic presentation of the talkers (i.e., same signal to each ear). The application of spatial auditory cueing for aviation tasks involving target detection/acquisition enhanced performance efficiency (Gunn, Warm, Nelson, Bolia, Schumsky & Corcoran, 2005; Tannen, Nelson, Bolia, Warm & Dember, 2004). These results suggest that spatial cueing could also augment performance in a sonar vigilance task where the operator is listening to competing sound sources.

5.3. Ambient Noise

The airborne sonar operator is usually exposed to high levels of ambient noise in the cockpit (Rood & James, 1999). From an operational perspective, high levels of ambient noise can impair monitoring efficiency in the detection of sonar targets. For example, the detection of low-frequency sonar targets could go unheard (i.e., masked) if they are near the dominant frequency region of the ambient noise source. Lowering the at-ear sound level of the ambient noise will increase the SNR of sonar targets that could lead to enhanced signal saliency. This can be achieved by using conventional or active noise reduction (ANR) hearing protection incorporated in the headset worn by the operator. Further enhancement may be achieved by integrating ANR and 3-D audio technologies, as proposed by Giguère, Abel & Arrabito (2000). Lower sound levels can extend the operator's exposure time to intense sounds (Moore, 1989) which could improve operator comfort and efficiency (e.g., earlier or more reliable target detection), predominantly when conducting long patrols.

5.4. Auditory Distractions

While monitoring sonar signals, a distracting event such as an auditory alarm (i.e., a signal intended to alert operators to the presence of a potential emergency) requires the operator to focus his/her attention to this new situation. The reallocation of attention to the distracting event could potentially lead to incidence of missed targets. The goal, therefore, is to minimize resources required to address the distracting event. Accurate encoding of urgency in auditory alarms through effective use of physical characteristics of the sound such as frequency composition, repetition rate, amplitude, and harmonic relation of the frequency components (e.g., Edworthy, Loxley, & Dennis, 1991; Hellier, Edworthy, & Dennis, 1993) may both increase the detectability and reduce the time required to address the alarmed condition without adding to workload (Haas & Casali, 1995; Sorkin, 1988). As the result, the disruption on operator efficiency when monitoring for sonar targets should be minimized.

5.5. Dual-Mode Displays

Sonar signals are presented either in the visual or auditory modality but rarely in both modalities simultaneously (known as a dual-mode display). Dual-mode displays have been evaluated for the detection and classification of simulated passive sonar signals (Colquhoun, 1975; Doll & Hanna, 1989; Kobus et al., 1986; Lewandowski & Kobus, 1989). A bimodal display has generally led to improve target detection and classification (Colquhoun, 1975; Doll & Hanna, 1989; Kobus et al., 1986; Lewandowski and Kobus, 1989). However, Kobus et al. (1986) did not show a statistically significant advantage for a bimodal display compared to the single best modality. The authors attributed their findings to the large differences in the spectral characteristics between the sonar targets.

6. IMPLEMENTATION CONSIDERATIONS

While the foregoing discussion on proposed methods for enhancing the saliency of aural signals are effective for increasing target detection, their utility in the vigilance domain for a real-world auditory sonar monitoring task has yet to be evaluated. We believe that the proposed methods could be implemented on most sonar systems. User performance for the detection of sonar targets should increase even further when the proposed methods are incorporated in conjunction with other countermeasures known for mitigating the vigilance decrement (Davies & Parasuraman, 1982; See et al., 1995; Warm, 1984, 1993). However, as sonar monitoring typically has a low event rate, special care is required for the development of training methods for tasks that have a low probability of occurrence of critical signals (Parasuraman, 1986). Other counter-measures such as injection of artificial signals may not be practical to employ in present-day sonar systems due to factors such as hardware limitations or cost. Hence, the viability of any countermeasure for a real-world sonar task remains the subject matter of future investigation.

Assessing the benefits of enhanced target saliency in a real-world sonar monitoring task may not be possible. As pointed out by Parasuraman (1986), the vigilance decrement is not the sole indicator of operator deficiency in a vigilance task. In operational tasks, the level of vigilance performance may be below a preset standard of performance, regardless of the decline in efficiency associated with time-on-task. For an operational sonar task, the calculation of the minimum level of efficiency is not practical due to the covert nature of the sonar environment. Upholding a preset minimum standard of user efficiency by employing methods to motivate the sonar operator (Fraser, 1953; Mackworth, 1950) would not suffice. The resource depletion alternative to the arousal model of the vigilance decrement (Helton et al., 2005; Johnson & Proctor, 2004; Warm & Dember, 1998; Warm et al., 1996) is important not only on a theoretical level but also on a practical level. Supervisors in the operational environment intuitively believe that the failure of target detection in vigilance results from the operator not monitoring the display because he/she was not attentive. If the decrement is to be modified in a sonar operational setting, supervisors must understand that the decrement may not be the result of lack of effort, but rather of resource depletion based upon task engagement. Recent studies using transcranial Doppler sonography (TCD), a noninvasive neuroimaging technique that employs ultrasound signals to monitor cerebral blood flow velocity (CBFV), provide additional support for the resource depletion model (for a review, see Warm & Parasuraman, 2007). These studies have revealed a corresponding decline in blood flow and user performance over the course of the vigil, and they provide empirical support for the notion that blood flow may represent a metabolic index of information processing resource utilization during sustained attention. A decline in CBFV occurs in comparable visual and auditory vigilance tasks (Shaw et al., 2006). TCD may offer a noninvasive and inexpensive tool to "monitor the monitor" and to help decide when operator vigilance has reached a point where task aiding is necessary or operators need to be given breaks or removed (Warm & Parasuraman, 2007). We predict that enhanced target saliency may help reduce resource depletion.

7. CONCLUSIONS

The existence of a decline in operator efficiency has been observed for some real-world monitoring tasks. Whether the decrement for the monitoring of aural sonar targets is as pervasive as those reported in laboratory studies requires further investigation. The practical implications of enhanced target saliency are an increase in the detection rate and potentially shorter latencies in the detection of targets. The financial cost of implementing the proposed methods should be offset by an expected increase in operator performance, potentially leading to tactical superiority in the continuing threat of underwater warfare.

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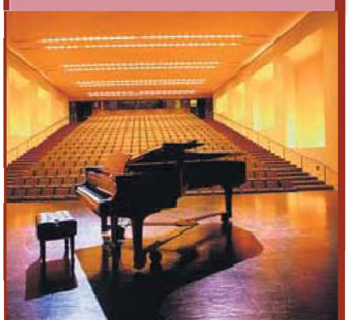

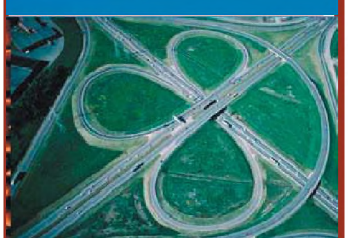

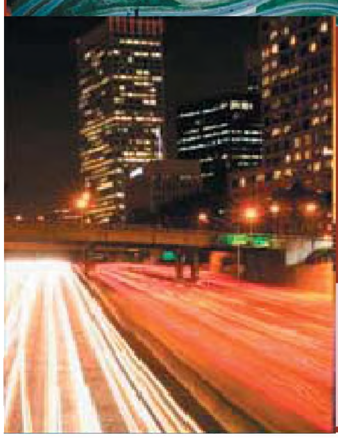

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MEASUREMENT CAPABILITIES

- Real time 1/1 & 1/3 octave frequency analysis
- Simultaneous display of several noise measurements—*ANY DATA* (Leq, Lmax, Spectra, etc
- Automatic logging of user selectable noise measurements (Leq, Lmax, Spectra, etc…)
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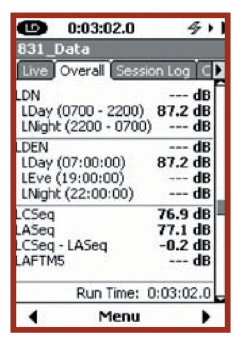

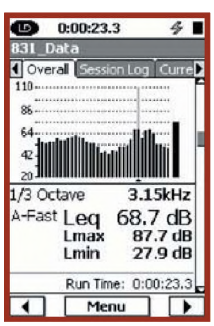

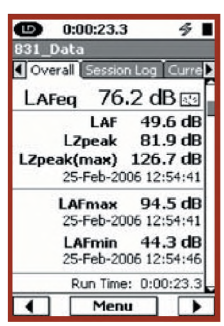

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Acoustical Performance Criteria, Treatment And Guidelines For Multifunctional School Gymnasia

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ABSTRACT

This paper identifies the acoustical requirements for multifunctional urban school gymnasia and discusses the lack of acoustic guidelines in achieving this objective. The requirement of compromise in determining such a criterion is also discussed in the light of recent ANSI standards. An alternative practical criterion for acceptable reverberation levels is established. The supporting case studies, measurements, analysis and discussions are presented.

SOMMAIRE

Cet article identifie les exigences acoustiques pour les gymnases d'écoles urbaines multifonctionnelles, et discute l'absence présente de critères acoustiques qui seraient requis pour atteindre ces objectifs. Compte tenu de l'avènement récent de nouveaux standards ANSI, il est aussi discuté de la nécessité d'un compromis au cours de la détermination de tels critères. Un critère pratique pour la détermination d'un temps de réverbération acceptable est établi. Les études de cas, prises de données, analyses et discussions pertinentes sont présentées.

1. Introduction

Growing programme demands and space requirements in urban schools require contemporary gymnasia to be multifunctional. Their diverse uses include sporting events, student assemblies, drama production, band concerts, and after school education/daycare to name a few. These uses fall into two broad categories namely, gymnasium use and auditorium use. Acoustical quality requirements for these two categories are unfortunately not quite the same. Gymnasium use suggests a level of acoustical liveliness while auditorium use requires speech intelligibility, which is defined as the percentage of speech material correctly identified by an average, normal-hearing listener working in their first language [1]. Satisfying one purpose degrades the acoustical quality requirement of the other and hence a compromise is vital.

Excessive background noise or reverberation in learning spaces interferes with speech communication and speech intelligibility and hence, presents an acoustical barrier to learning [1, 2]. ANSI standard S12.60-2002 was released in 2002 to address this issue. It focuses on three main acoustical characteristics to improve speech intelligibility in classrooms. These characteristics are background noise, noise isolation, and reverberation.

As stated in the standard itself, it can be effectively used in new school development or major renovation of existing classrooms. In those situations, the acoustical designer has good control over the influencing parameters. Background noise can be controlled effectively by considering the HVAC system, in-class equipment, and outside student activities, etc. at the design stage. Noise isolation is achieved by properly incorporating rated sound transmission class (STC) and impact insulation class (IIC) walls and ceiling assemblies to effectively control air-borne and structure-borne noise. The other parameter that influences the speech intelligibly is the reverberation, which determines the characteristic of sound within the space considered. The reverberation depends on the physical dimensions of the space as well as the acoustical characteristic of materials that form the interior special envelope [6].

In established schools, a complete overhaul of the gymnasia may not be possible because of the economic and time considerations, and hence control over all the influencing acoustical parameters may not be possible. In these circumstances, acoustical treatments are generally considered as a viable alternative. The introduction of varying amounts of acoustically absorptive materials on the interior surfaces of the walls and ceiling is the basic method of acoustical treatment [3]. The placement of the absorptive materials is also important. Absorptive materials are specified by the area of coverage, the acoustical absorption coefficients in octave bands (α) and the Noise Reduction Coefficient (NRC).

The reverberation time (RT60) has traditionally been the key factor in quantifying the acoustic environment [3]. In most teaching spaces, the optimum reverberation should be fairly low (approximately 0.6 s, [2]), so that reflected sound decays rapidly, which allows for better speech conditions. In spaces for sporting or music events, longer reverberation times have been found to be preferred (up to 2.4 s [7]) in-order to provide some excitement and liveliness.

This paper establishes a criterion for acceptable reverberation time limit for multifunctional gymnasia and provides treatment guidelines to achieve this criterion. A few case studies of Greater Toronto Area (GTA) school gymnasia are included.

2 ASSESSMENT CRITERIA

As noted in the literature [3,7] an RT60 at the low end of the range may provide acceptable speech intelligibility in a classroom or lecture room-like setting with students at a relatively close distance, but is likely to detract from the excitement of an athletic competition or the enjoyment of a music recital. Thus, setting an assessment criterion for a gym, which must accommodate varied activities, is not straightforward. Published literature suggests that the optimum range for good speech intelligibility is 0.6 to 2.0 s, (for classroom, lecture hall, small theatre-like settings and 0.6 s being ideal for core learning spaces) while the optimum range for a 'live' space such as auditorium, concert hall, symphonic, etc. is from 1.4 to 2.6 s [2, 3, 6, 7]. Thus a compromise is required for multifunctional gymnasia in order to serve both purposes.

Achieving an RT60 of 2.0 s or less across the speech frequency range would be a reasonable target without significantly compromising speech intelligibility [3]. Whereas, achieving an RT 60 of 1.5 s or more would be considered as a reasonable target without significantly compromising the excitement required for regular gym activities. Slightly longer reverberation times at lower frequencies are acceptable, as this will have little effect on either overall levels or intelligibility. Similarly shorter reverberation at high frequencies are typical due to the large physical volumes and air absorption without degrading speech intelligibility or the quality required for excitement.

In this assessment a reverberation scaling curve generally used for audio engineering [9] was applied to a 1.5 s (at 500Hz) lower limit for speech intelligibility, and a 2.0 s (at 500Hz) upper limit for other regular gym activities. These were used to set a recommended lower and upper limit of the reverberation criteria between frequencies of 125 Hz and 4000 Hz. These limits are shown in Figure 1.

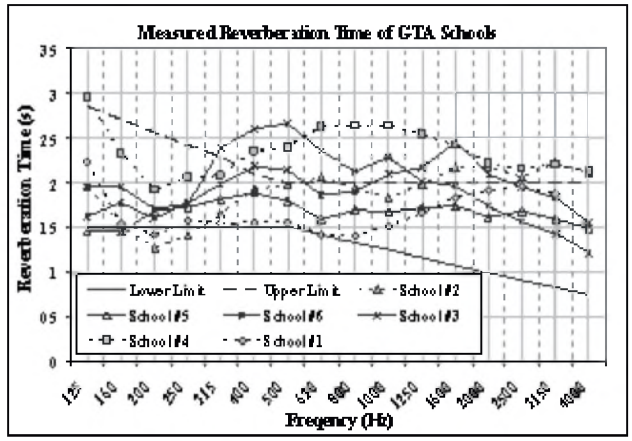

Figure 1: Assessment criteria and Measured Reverberation Time of six GTA Schools

3 SELECTED GYMNASIA AND REVERBERATION TIME MEASUREMENTS

Six GTA school gymnasia were selected based primarily on availability and tested using standard testing procedures. The gymnasia and test methods are described below.

3.1 DESCRIPTION OF THE GYMNASIA AND REVERBERATION MEASUREMENTS

The schools are referred in this paper as School #1, School #2, School #3, School #4, School #5, and School #6. The surface materials on the walls, floors and ceilings of those gymnasia are given in Table 1. School #1 and School #6 have acoustic steel roof decks, School #2 and School #4 have regular (non-acoustic) steel roof decks and School #3 and School #5 have Brand Name Commercial Product (BNCP) roof decks. All schools have acoustically similar floors. School #1, School #3 and School #4 have BNCP wall panels of varying coverage. School #2 and School #6 incorporate sound absorbing masonry units in the walls.

Discussion with school personnel indicated that School #1 and School #5 have recently been improved to a satisfac-

Table 1: Summary of Test Gymnasia – Major Surface Materials

School	Roof	Wall	Floor
School #1	Acoustic steel deck	Painted masonry, acoustic wall panels	Resilient tile on concrete
School #2	Steel deck	Standard painted block, acoustic masonry units (AMU type1), Solid Vinyl	Varnished Hardwood Floor
School #3	"BNCP" deck	Hard brick, painted block, acoustic wall panels.	Varnished Hardwood Floor
School #4	Steel deck	Acoustic wall panels and hardwood panels	Varnished Hardwood Floor
School #5	"BNCP" deck	Standard gypsum drywall	Varnished Hardwood Floor
School #6	Acoustic steel deck	Painted masonry and (AMU type2)	Varnished Hardwood Floor

Note: in addition, other wall materials such as masonry, brick, glass, wood, drywall, etc. were appropriately accounted for along with the area they cover in each wall.

tory level from their original state after acoustical treatment. Other schools' staff indicated that the gymnasia were either recently constructed or have had some remedial treatment but there is still room for improvement. HGC Engineering did not have an opportunity to test those gymnasia before treatment which might have taken place years ago. It was noted that, in most cases, only portions of walls have been acoustically treated. The lack of treatment in the vertical direction (floor and ceiling) can similarly cause poor performance, which will be discussed in detail in the subsequent sections.

3.2 MEASUREMENT METHODOLOGY

Standardized reverberation measurements were conducted in the six school gymnasia pursuant to the methodologies described by ISO 3382-1997, "Acoustics - Measurement of the reverberation time of rooms with reference to other acoustical parameters". The measurements were made using a Brüel & Kjær condenser microphone (Type 4188, S/N 2140820) interfaced to a Hewlett-Packard Dual Channel Real Time Frequency Analyzer (Model 3569A, S/N 3442A00141). The measurement channel was correctly calibrated before and after the measurements using a Brüel & Kjær sound level calibrator (Model 4231, S/N 2170332). Reverberation measurements were performed using the decay rate method based on ASTM C423, as prescribed in E1007.

As discussed by Bradley [8], acoustic measurements are generally done, a) to compare with design criteria and to evaluate whether the design target has been achieved, b) to better understand acoustical phenomena of the space, or c) to diagnose the cause of identified acoustical problems. Accordingly the measurements and data processing will depend on the purpose of the measurements. As the objective here was to compare various gymnasia with a performance criterion and to evaluate/compare their acoustical qualities, hall-average values of the acoustical measurements were used.

Our reverberation measurements at the school gymnasia are also given in Figure 1 along with the criteria.

4 ANALYSIS AND DISCUSSION

Our measurements and subsequent theoretical modeling based on the observed materials and their published absorption properties are shown in Figures 2 to 8. The modeling used Sabine theory, modified to consider three dimensional effects using Fitzroy analysis, appropriate for larger rectangular spaces. It should be noted that in addition to major absorptive materials (Table 1), the analysis also includes general construction materials as noted during the visits, for which data are well established.

RT at 500 Hz has traditionally been used to compare acoustical performance mainly for simplicity. Figure 2 compares RT (at 500 Hz) of each school with criteria. It indicates that schools #1 and # 5 satisfy the criteria while school #2 also marginally satisfies. Schools #3, #4, and #6 exhibits excessive RT, making it only suitable for sporting events.

As indicated in Table 1, School #2 has no significant sound absorptive material except acoustically absorptive slotted masonry units (AMU-type1) on portions of walls. Although this gym has acoustical qualities that are acceptable for sporting activities, speech intelligibility is compromised especially at high frequencies (See Figure 4). As indicated in Table 2, the AMUs do not have significant high frequency absorption, and the area of coverage is insufficient.

School #3 and School #4 exhibited excessive RT in the mid frequency bands, School #3 has absorptive roof deck (BNCP roof deck) covering the whole ceiling area, but it has no significant absorptive material on any of the walls. Although this BNCP roof deck has good high frequency absorption, their absorption coefficients in the mid bands are less than 0.5. Due to these reasons School #3 exhibits some excess in the mid frequency band reverberation. School #4 has a few clustered BNCP wall panels as the only absorptive materials covering approximately 45 % of the wall area. The absorption of these panels is good, but the lack of absorption in the vertical direction and insufficient area of coverage in other directions, results in the excessive reverberation.

School #1 has acoustic roof deck and scattered BNCP acoustic wall panels, covering 11% of the wall area. School #5 has BNCP acoustic roof deck and standard drywall on the walls. Both of these gymnasia exhibit good performance and satisfy the criteria.

School #6 has 31 % of the wall covered by AMUs (type 2) and an acoustic roof deck. Both the AMUs (type 2) and

Table 2: Absorption Coefficients of Selected Materials used in the Analysis

Material	125	250	500	1k	2k	4k	NRC
Steel Roof Deck	0.07	0.30	0.15	0.18	0.15	0.13	0.20
BNCP Roof Deck 3" (School #5- 100% of ceiling)	0.21	0.41	1.00	0.75	1.00	0.97	0.80
BNCP Ceiling 1" x 24" x 24" (School #3 - 100% ceiling)	0.40	0.42	0.35	0.48	0.60	0.93	0.45
BNCP Wall 1" C-20 (School #4 - 45% wall, School #1 - 11% wall)	0.16	0.43	1.00	1.05	0.79	0.98	0.80
30" wide 1.5" flute acoustic deck (School #6 - 100% roof deck)	0.52	0.96	1.05	0.91	0.61	0.30	0.90
Acoustic deck (School #1 - 100% roof deck)	0.33	0.75	1.01	0.92	0.55	0.33	0.80
(AMU type2) (School #6 - 31% wall)	0.57	0.76	0.99	0.94	0.54	0.59	0.80
(AMU type1) (School #2 -25 % wall)	0.20	0.88	0.63	0.65	0.52	0.43	0.65
Revised Coefficients Correlated to Measurements							
Revised Coefficient School #1 Roof Deck	0.25	0.60	0.30	0.30	0.20	0.01	0.35
Revised Coefficient School #6 Roof Deck	0.40	0.30	0.20	0.20	0.14	0.06	0.20

acoustic roof deck have good low frequency absorption but have less high frequency absorption. In addition AMUs (type 2) cover only 31% of the wall area. Due to these reasons, there are relatively high levels of reverberation.

Generally it is noted that four of the theoretical models (School #2, School #3, School #4 and School #5) are in very good agreement with the measurements, while two of the theoretical models (School #1 and School #6) do not correlate well with the measurements. These models predict much lower levels of reverberation than actually measured. This imply that one or more of the materials forming the special envelop absorb less energy than theoretically expected. A sensitive parameter analysis on material coefficients indicates that the roof decks of School #1 and School #6 do not provide as much absorption in situ as would be indicated by published absorption data. Good agreement with measurements is only achieved if significantly lower absorption coefficients are used as shown in Figures 9 and 10.

The discrepancy in material performance is a common phenomenon that can be expected in old/existing schools, mainly due to lack of acoustical consideration in the past, poor maintenance. This indicates improvement to these gymnasia based on the observed and published manufacturers' absorption coefficients will not result in the expected performance. It is possible that the holes in the flutes of the deck may be partially filled with paint or some other aspect of its installation has caused it to absorb less sound than expected, e.g. if the fibreglass insulation strips were not installed in the flutes of the deck, as specified by the manufacturer.

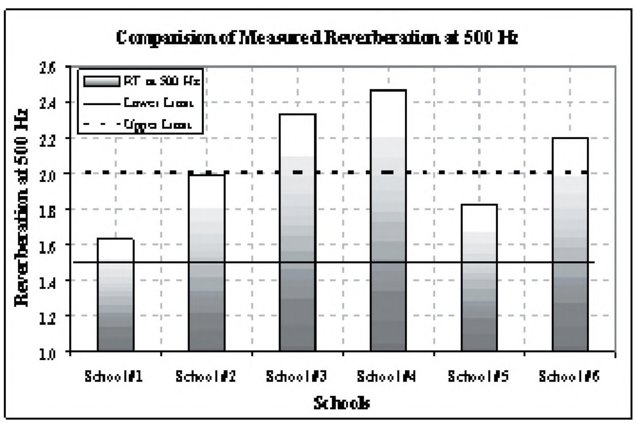

Figure 2: Measured Reverberation Time of six GTA Schools

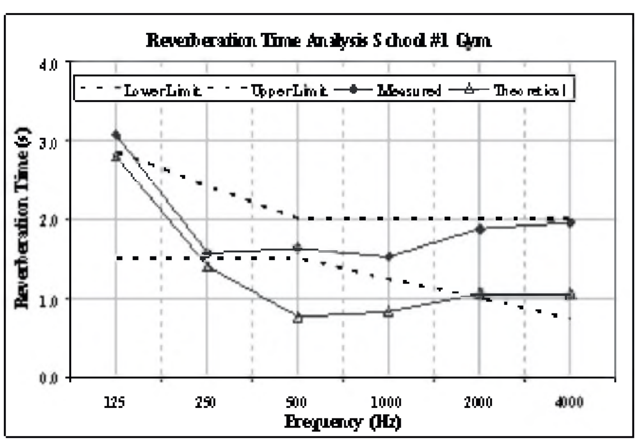

Figure 3: Measured and Theoretical Reverberation Time for School #1 Gym.

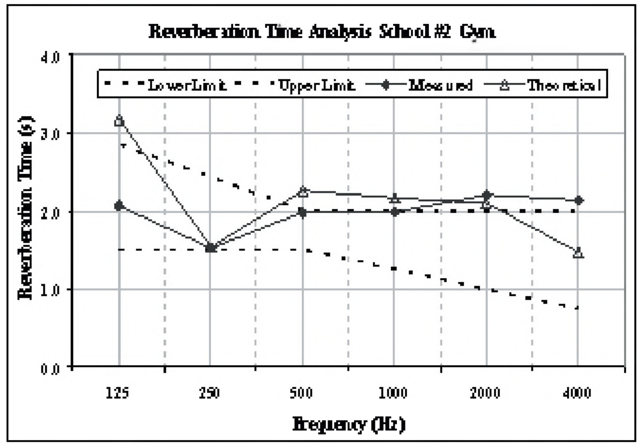

Figure 4: Measured and Theoretical Reverberation Time for School #2 Gym.

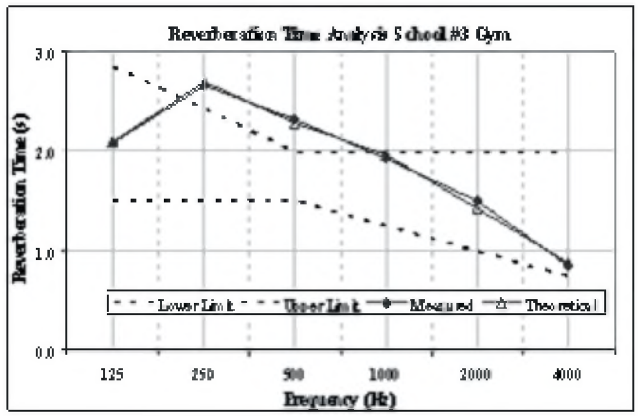

Figure 5: Measured and Theoretical Reverberation Time for School #3 Gym.

Improvements through renovation can be effective if the required absorption is estimated based on reliable reverberation measurements and suitable material is selected considering the performance in the frequency bands of interest. In addition, the optimal performance also depends on the area of coverage, absorption coefficients and distribution of the

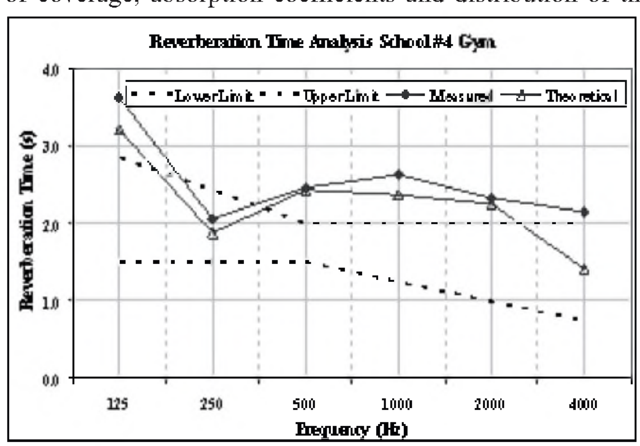

Figure 6: Measured and Theoretical Reverberation Time for School #4 Gym.

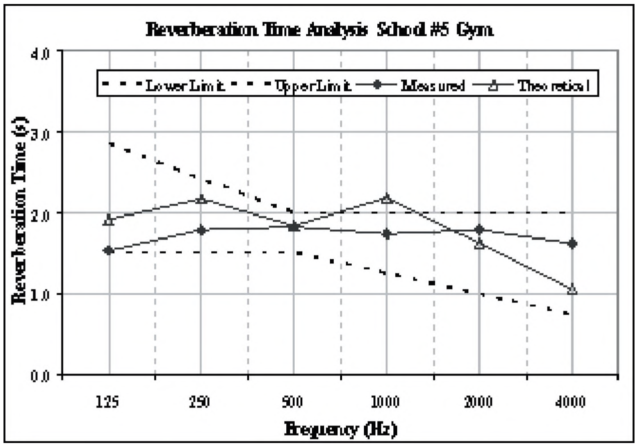

Figure 7: Measured and Theoretical Reverberation Time for School #5 Gym.

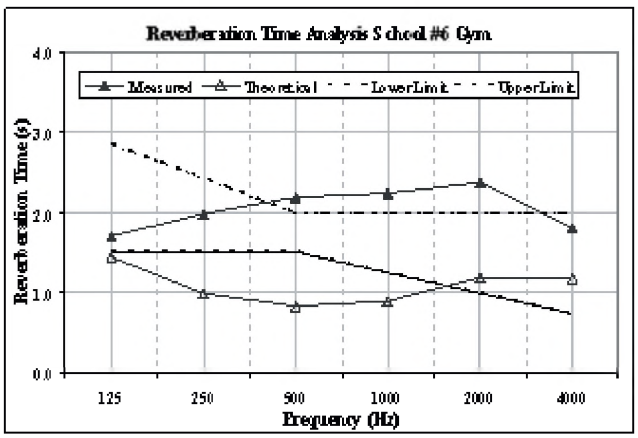

Figure 8: Measured and Theoretical Reverberation Time for School #6 Gym.

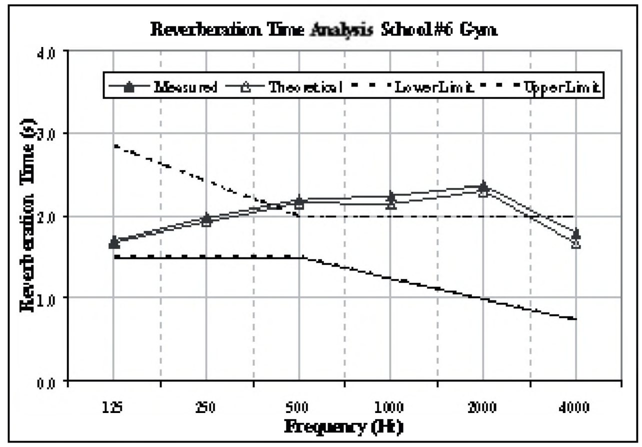

Figure 9: Measured and Theoretical Reverberation Time for School #6 Gym with modified roof absorption coefficients

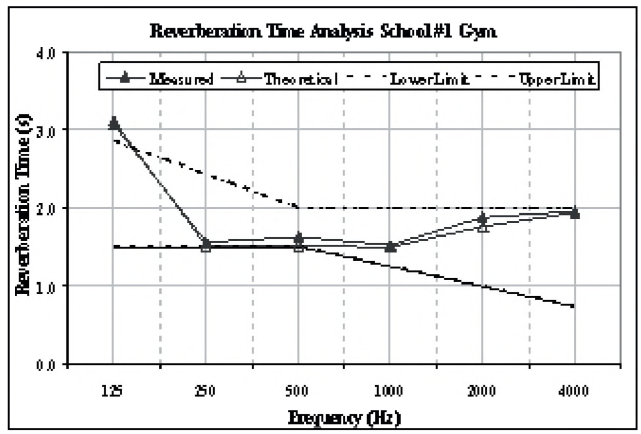

Figure 10: Measured and Theoretical Reverberation Time for School #1 Gym with modified roof absorption coefficients

absorptive materials.

5 ACOUSTIC TREATMENT GUIDELINES

The new ANSI standard does not specify performance criteria for larger enclosed learning spaces such as gymnasia in detail. As discussed previously, converting a gymnasium for multiple use (or multifunctional) is challenging but becoming an essential investment due to growing program and space requirements in most urban schools. Existing gymnasia were generally designed for sporting events, having less acoustical treatments than required for other activities.

In this paper, means of acoustically treating a gymnasium are investigated and discussed. It is assumed that the background sound level generated by HVAC and other sources has been properly controlled incorporating appropriate rated enclosures (wall, window, ceiling assemblies, etc., meeting or exceeding required minimum STC ratings), and silencers, etc. Under these circumstances, the significant issue for a gymnasium to be multi-functional is the reverberation.

Achieving acoustic control equal to the level of a regular classroom is challenging, practically and economically, and in most of the cases, not warranted.

Therefore, in order to achieve good acoustics in a multi-functional gymnasium a five step guideline is proposed:

1. Determine the existing acoustic treatments and measure the levels of reverberation to confirm their performance.
2. Determine the additional absorption required to achieve the criterion given in Section 2
3. Choose the absorptive treatments considering their low, mid and high frequency absorption coefficients and the level of reverberation already present in those frequency bands.
4. Determine an appropriate distribution of material based on acoustical modelling which considers all three directions (generally it is advisable to distribute the materials fairly evenly around the wall and ceiling considering the existing level of abortion in each direction), and confirm the resulting reverberation levels through testing after installation.
5. Ensure that the installation proceeds as per the manufacturer's recommendations or the materials may not achieve the desired level of absorption and excessive reverberation could result.

6 CONCLUSIONS

This paper identifies the acoustical requirements for multi-functional urban school gymnasia and discusses the lack of acoustic guidelines in achieving this objective. The requirement of compromise in determining such a criterion is also discussed in light of recent ANSI standards. Criteria for acceptable reverberation levels are suggested. Through an investigation of a number of gymnasia in the Toronto area, a five step guideline for the successful design of a new facility and the remedial treatment of an existing facility has been developed. The supporting case studies, measurements, analysis and discussions are presented.

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Acoustics Standards Activity In Canada
2007 Update And Invitation To Participate

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ABSTRACT

CSA currently has 10 Acoustics Standards and three more with significant acoustics content. Over five times that number of international acoustics standards have been reviewed and endorsed in a new Canadian Standard, Z107.10. This innovative standard streamlines the process whereby CSA endorses standards suitable for use in Canada from other organisations, such as ANSI and ISO. This article is an update for 2007 of Acoustics Standards activities in Canada, especially those of the Canadian Standards Association. Canadian acousticians are invited to contact the author to become more involved with the many acoustics standards activities currently underway in Canada and on behalf of Canada around the world.

SOMMAIRE

L'Association canadienne de normalisation (ACNOR) a présentement dix normes acoustiques et 3 autres comportant un contenu acoustique important. Plus de cinq fois ce nombre de normes acoustiques internationales ont été revues et sont endossées dans une nouvelle Norme Canadienne, Z107.10. Cette norme innovatrice améliore le processus par lequel CSA approuve des normes des autres organisations (par exemple ANSI ou ISO) comme étant acceptable pour une utilisation au Canada. Cet article est une mise à jour des activités de normalisation en acoustique au Canada pour 2007, spécialement celles de l'ACNOR. Les acousticiens canadiens sont invités à contacter l'auteur pour s'impliquer dans les nombreuses activités en rapport avec les normes acoustiques actuellement en cours au Canada et au nom du Canada partout dans le monde.

1. Introduction

It is hard to practice acoustics (or many other disciplines) without interacting with consensus standards such as those produced by CSA, ISO, ANSI, IEC and similar bodies. They define the units we use, the weightings, the instruments. They provide measurement and calculation procedures to allow one practitioner's work to be compared with another. Imagine what it would be like if each measurement had to be described without the use of standard nomenclature, units, instruments, procedures. Reports would be much longer and the huge variety of different measurements would make it extremely difficult to reproduce others' work. Specifying or limiting sound levels would become virtually impossible without agreed and recognised ways to measure and describe sound.

The Canadian Standards Association (CSA) Technical Committee Z107 – Acoustics and Noise Control and its subcommittees look after all but one of the 10 Canadian Acoustics Standards (the exception is Z94.2 Hearing Protection Devices, which has its own technical committee). Z107 also coordinates all Canadian acoustics standards activity, with representatives from the Hearing Protection Technical Committee and from Canada's international standards advisory committees providing liaison to their activities. It also reviews international standards and endorses those found relevant and useful for Canada.

The goal of this article is to inform Canadian acousticians of progress in Canadian Standards activities and to invite those who are interested to become more involved with these activities. Participation is one of the best ways to stay in touch with this fast moving field and an excellent way to meet those who are leading it in many fields. Any acoustician interested in becoming involved with Acoustics standards in Canada is invited to contact the author or any of the subcommittee chairs. Most chairs welcome newcomers willing to work and the work need not involve a lot of time.

2. Z107.10 Omnibus Standard

The most important recent change to Acoustical Standards in Canada is the 2006 publication of Z107.10, Guide for the Use of Acoustical Standards in Canada, a new omnibus standard by Cameron Sherry and his Editorial Subcommittee. The standard summarises all acoustics standards in which Z107 has an interest, including CSA standards, and those ISO, ASTM, ANSI and IEC standards that Z107 considers of importance to Ca nada. This gives the reader a single source for information relating to Acoustics standards of interest to Canada, including those referred to by regulations and guidelines within Canada. Given the speed with which ISO and other groups are changing standards, this new approach is not only convenient, it is essential, and the intent is to issue revisions annually.

This year the new standards added include ANSI 12.60 on Classroom Acoustics. This standard, available free from ANSI, fill an important need in North American classrooms. Other standards include:

- ISO 1999 – 1990 Acoustics - Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment.
- ISO 7574 –1:1985 Acoustics -- Statistical Methods for Determining and
Verifying Stated Noise Emission Values of Machinery and Equipment
- ISO 11689:1996 – Acoustics -- Procedure for the Comparison of Noise-Emission Data for Machinery and Equipment
- ISO 11690 – 1:1996 – Acoustics -- Recommended Practice for the Design of
Low-Noise Workplaces Containing Machinery
- ISO 11820:1996 – Acoustics -- Measurements on Silencers in Situ
- ISO 12001:1996 - Acoustics -- Noise Emitted by Machinery and Equipment --
Rules for the Drafting and Presentation of a Noise Test Code
- ISO 15664: 2001 -- Acoustics -- Noise Control Design Procedures for Open Plant

Z107.10 is an important innovation in standards review in Canada. For many applications there is no need to write a Canadian Acoustics Standard. Many international standards are well written by highly qualified technical committees and their use here helps simplify communication with international acousticians and acoustics done in Canada by global organisations. Canada, and most other countries, could not afford to prepare the variety of standards available internationally. It also cannot afford to ignore them.

Until now, standards from outside Canada were either endorsed or adopted singly, a time consuming process whereby each standard was reviewed and balloted and in some cases published with small changes required for the Canadian context. The new standard streamlines this process considerably and is the first of its kind in Canada, addressing an important need in allowing Canadian users more ready access to Acoustics standards around the world.

An example will give an idea of what level of detail Z107.10 contains for each standard it lists:

ANSI S12.60-2002

Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools

This Standard provides acoustical performance criteria, design requirements, and design guidelines for new school classrooms and other learning spaces. These criteria, requirements, and guidelines are intended to provide the acoustical qualities needed to achieve a high degree of speech intelligibility in learning spaces. The standard may be applied to the design of new learning spaces, or (in some cases) to the renovation of existing classrooms. Informative annexes provide design guidelines that are intended to aid in conforming to the design requirements. Test procedures for verifying conformance to this standard are also suggested in an annex.

*(Copies of the document may be downloaded (free of charge). The Standard is available through the ASA Standards Store at http://asastore.aip.org/.

This example shows an entry for an ANSI standard newly proposed for use in Canada. It describes the standard, its results and the relevance in a Canadian context.

3. Committee Activities

3.1 Z107 Acoustics and Noise Control

The Z107 main committee meets once a year, usually during the Canadian Acoustics Week. Its executive, consisting of all the subcommittee chairs and representatives of other committees, meets in the spring, either in person or by teleconference. Most other work is done by e-mail. The main committee reviews progress by each subcommittee and votes on any new work proposals. The main committee is also the last technical hurdle for a standard before CSA editors put it into final form. The steering committee, to which the main committee reports, approves work and reviews completed standards; however they cannot make technical changes.

Most work is done within the Z107 subcommittees, which are responsible for the following standards:

Hearing Measurement, chaired by Alberto Behar, responsible for CAN3-Z107.4-M86 Pure Tone Air Conduction Audiometers for Hearing Conservation and for Screening and CAN/CSA-Z107.6-M90 Pure Tone Air Conduction Threshold Audiometry for Hearing Conservation

Vibration, chaired by Tony Brammer, provides liaison between Z107 and the Technical Advisory Committee of Standards Council on ISO standards on vibration. Tony is active on the ISO group for ISO 2631, the definitive standard on measurement of whole body vibration.

Occupational Noise, chaired by Stephen Bly, is responsible for the following standards :

- Z107.52-M1983 (R1994) Recommended Practice for the Prediction of Sound Pressure Levels in Large Rooms Containing Sound Sources. This standard is in need of major updating and a chair is being sought to do this work. The intent is to provide guidance to Canadian industry on how to design quiet plants. It is seen as building upon Z107.58, which provides advice on buying quiet equipment.
- A new version of Z107.56-94 Procedures for the Measurement of Occupational Noise Exposure, was published in 2006. It is referenced in Federal and some provincial regulations. Recently, at least in part due to

recommendations by Z107, both Manitoba and Ontario adopted a 3 dB exchange rate and dropped impulsive noise limits, leaving Quebec as the only major Canadian province still using the 5 dB exchange rate.

- Z107.58-2002 Noise Emission Declarations for Machinery, was written by a group chaired by Stephen Bly. It is a voluntary guide on noise emission declarations for machinery to be used in Canada and is compatible with European regulations allowing Canadian machinery to be sold into that market. A Noise Emission Declaration is a statement of sound levels produced by equipment, which would usually be included with the instruction or maintenance manual and in technical sales literature. Measurements are made according to ISO standards and include estimates of the likely variability of the measurements. Canada recommends use of a declaration stating the level and uncertainty as two numbers, rather than adding them together into a single number as is sometimes done elsewhere.

Environmental Noise, chaired by Bill Gastmeier has responsibility for environmental noise standards formerly handled by Industrial Noise, Transportation Noise and Powered Machines. These include:

- Z107.53-M1982 (R1994) Procedure for Performing a Survey of Sound Due to Industrial, Institutional, or Commercial Activities. This standard is being replaced with the ISO1996 series, which were the last ISO Acoustics standards endorsed separately, before Z107.10 took over that role1,2.
- CAN3-Z107.54-M85 (R1993) Procedure for Measurement of Sound and Vibration Due to Blasting Operations. A working group, chaired by Vic Schroter, is revising this standard.
- CAN/CSA-Z107.55-M86 Recommended Practice for the Prediction of Sound Levels Received at a Distance from an Industrial Plant. This standard is being revised to provide a simple alternative to ISO 9613(2) and to explain when each is best used.
- CAN/CSA-Z107.9-00: Standard for Certification of Noise Barriers. This standard was written by a group chaired by Soren Pedersen. It provides municipalities, developers, road and highway departments, railways and industry with a standard specification which can be used to define the construction of barriers intended to be durable enough for long term use in Canadian conditions. It has been widely cited in both Canada and the US.
- The US Department of Transportation, Federal Highway Administration, "Highway Noise Barrier Design Handbook" is already harmonized with the CSA standard, as are several Ontario municipalities, the Ministry of Transportation of Ontario, and numerous US state transportation agencies, making this the de-facto standard for barriers across North America.

Wind Turbines – A group chaired by Brian Howe is assisting the CSA wind turbine committee with the acoustical aspects of their standards, specifically with adopting the ISO measurement procedures in ISO 61400.

Editorial, chaired by Cameron Sherry, (which reviews all proposed standards) and is responsible for reviewing and endorsing ANSI S1.1-1994 Acoustical Terminology. In addition, they have ongoing responsibility for updating the omnibus standard Z107.10 using input from each subcommittee. Cameron is actively looking for new members to assist in this work and can be contacted directly or through the author. It would be a great way to quickly gain an overview on some of the most important acoustics standards in Canada and the world.

Sound Quality is a new group chaired by Colin Novak and concerned with sound quality standards, primarily aimed at the automotive industry but becoming increasingly useful in other areas.

Z107 also has subcommittees providing liaison with International Standards activities, specifically steering committees in Building Acoustics, Instrumentation, Acoustics and Noise. These Steering committees are run by the Standards Council of Canada and are harmonised with the Z107 committee to which they report regularly on progress and upcoming issues. Draft international standards are provided on a private website to which steering committee members have access in order to review them and recommend Canada's position.

Building Acoustics, chaired by David Quirt, does not have its own CSA standards, but reviews other standards from a Canadian viewpoint, mostly those from ASTM and ISO. David Quirt is chair (and Z107 liaison) of the Standards Council of Canada Steering Committee for ISO TC 43 SC2, Building Acoustics. Members of this group are active on many ASTM and ISO building acoustics groups. Their main issue in the next few years will be the balance between the technically superior ISO standards and the ASTM standards which are important for North American trade. They also recommend Canadian endorsed standards on building acoustics (a large part of the current Z107.10 list) and prepare appropriate entries.

Instrumentation and Calibration: George Wong, is the chairman (and the CSA liaison) for the Standards Council of Canada Canadian Subcommittee of IEC/TC 29: Electroacoustics. He is seconded at present by Leo Wu. This group deals with all instrumentation pertaining to acoustical measurements, such as WG 4: Sound level meters; WG 5: Microphones; WG 10: Audiometers; WG 13: Hearing aids; WG 17: Sound calibrators; WG 21: Ear simulators; and maintenance teams (MT) MT19: Filters; and MT20: Hearing aids induction loops. All of the above international Working Groups have Canadian members.

The Canadian Steering Committee for ISO TC43 (Acoustics) and TC43(1)(Noise) is chaired by Stephen Keith, who provides Canadian comments, votes on ISO standards and coordinates the work of Canadian representatives on several ISO working groups. This group deals with ISO Standards on measurement and assessment of sound and hearing, such as WG 17: Hearing protectors WG28: Machinery noise emission standards (referenced in CSA Z107.58) WG 40: Impulsive sound propagation for environmental noise assessment, WG 45: Acquisition of data pertinent to land use, and WG 53: Occupational Noise Exposure. All of the above international Working Groups have Canadian members.

All these groups are always interested in new members willing to work.

Z94 – Hearing Protection

The other CSA Acoustics Standards Committee, the Hearing Protection Technical Committee is responsible for the Z94.2-02 Standard: Hearing Protection Devices – Performance, Selection Care and Use , widely referred to in Canadian occupational noise regulations. They major new version of this standard was issued in January 2002 that includes changes to the ANSI hearing protector standards and procedures. This will mean the introduction of user-fit hearing protector measurements, similar to those used by ANSI and now recognized as being more representative of how hearing protectors are used in practice than the old technician-fitted testing methods. This standard includes also extensive practical information for users on how to select and use hearing protectors.
Canadian Acoustics Standards

Table 1 shows all the Canadian Standards currently in force and also lists three standards with significant acoustical content. This table may also soon be found at the CAA website and will be kept up to date there. Meanwhile the list can be found at
http://www.csa-intl.org/onlinestore/GetCatalogDrillDown.asp?Parent=430

Table 1- CSA Acoustics Standards

CAN3-Z107.4-M86 Pure Tone Air Conduction Audiometers for Hearing Conservation and for Screening / Audiomètres tonals à conduction aérienne pour la préservation de l'ouïe et pour le dépistage
CAN/CSA-Z107.6-M90 Pure Tone Air Conduction Threshold Audiometry for Hearing Conservation
CAN/CSA-Z107.9-00: Standard for Certification of Noise Barriers
Z107.10 Guide for the Use of Acoustical Standards in Canada,
Z107.52-M1983 (R1994) Recommended Practice for the Prediction of Sound Pressure Levels in Large Rooms Containing Sound Sources
Z107.53-M1982 (R1994) Procedure for Performing a Survey of Sound Due to Industrial, Institutional, or Commercial Activities (soon to be replaced by ISO 1996).
CAN3-Z107.54-M85 (R1993) Procedure for Measurement of Sound and Vibration Due to Blasting Operations / Méthode de mesure du niveau sonore et des vibrations émanant des opérations de dynamitage
CAN/CSA-Z107.55-M86 Recommended Practice for the Prediction of Sound Levels Received at a Distance from an Industrial Plant / Pratique recommandée pour la prévision des niveaux sonores reçus à une distance donnée d'une usine
Z107.56-06 Procedures for the Measurement of Occupational Noise Exposure / Méthode de mesure de l'exposition au bruit en milieux de travail
Z107.58-2002 Noise Emission Declarations for Machinery
Z94.2-02 • Hearing Protection Devices - Performance, Selection, Care, and Use / Protecteurs auditifs
Standards with Acoustics Component:
Z62.1-95 Chain Saws
CAN/CSA-Z412-M00 Office Ergonomics / L'ergonomie au bureau
CAN/CSA-M5131-97 (R2002)Acoustics - Tractors and Machinery for Agriculture and Forestry - Measurement of Noise at the Operator's Position - Survey Method (Adopted ISO 5131:1996)

Endorsed Standards (Over 50 standards listed in Z107.10)

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SPATIAL VIBRATION PATTERNS OF THE GERBIL EARDRUM

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1. INTRODUCTION

Located between the external ear and the inner ear, the middle ear extends from the eardrum to the oval window and includes a chain of three ossicles (malleus, incus and stapes) suspended in an air-filled cavity. The middle ear plays a key role in hearing and is the site of many infections, congenital defects, injuries and other diseases that contribute to hearing loss. To date, non-invasive diagnostic procedures and the quality of middle-ear prostheses are often inadequate. A better understanding of middle-ear mechanics would contribute to advancements in diagnosis and treatment of hearing loss. To this end, many groups have conducted research on mammalian middle ears. Gerbils in particular have become widely used in this field.

Studies investigating eardrum vibrations in mammalian ears have shown simple vibration patterns at low frequencies and more complex ones at high frequencies (Tondorf & Khanna, 1972; Decraemer & Khanna, 1996; Rosowski et al., 2007). The motion of the malleus-incus complex has traditionally been described as a simple rigid rotation around a fixed axis (Békésy, 1960), but studies in cats have shown evidence of shifting of the axis of rotation, and of manubrial bending at high frequencies (Decraemer et al., 1991 & 1994; Funnell et al., 1992). There is, however, a lack of such data for the gerbil.

The use of laser Doppler vibrometry (LDV) has become very common in the study of middle-ear vibrations. LDV is an optical technique used to measure the velocity of a vibrating surface at the nanometer level without mass loading. In this work we present LDV measurements at multiple points along the manubrium of the malleus and along a line on the eardrum perpendicular to the manubrium, in order to study the spatial vibration patterns.

2. MATERIALS AND METHODS

Measurements were carried out on 5 Mongolian gerbils (*Meriones unguiculatus*) from Charles-River (St-Constant, QC). The experimental protocol is described briefly here; a more detailed description was given by Ellaham et al. (2007).

After the gerbil is sacrificed and decapitated, the lower jaw is removed to expose the bulla which encloses the middle-ear cavity. The external ear is removed and parts of the bony ear canal are drilled away to maximize exposure of the tympanic membrane and to reveal the umbo (Fig. 1). A large hole is drilled in the bulla to equalize the pressures on the two sides of the eardrum, and to permit experimental steps to correct for temporal effects (Ellaham et al., 2007).

The gerbil head is attached to a coupler with dental cement at the opening of the ear canal with an orientation that allows an optimal view of the eardrum (Fig. 1). The coupler is an acoustically sealed aluminum cavity. An ER-2 Tube-phone (Etymōtic Research) is used for sound delivery and an ER-7C probe-microphone system (Etymōtic Research) is used to monitor the sound pressure level (SPL) at 2 to 3 mm from the eardrum. A 15-cm PE-50 tube (I.D. = 0.58mm, O.D. = 0.96mm) is used as a vent to prevent static pressure from building up inside the coupler. An antireflection-coated glass window (T47-518, Edmund Optics) covers the top of the cavity. Measurements are performed inside a double-walled sound-proof room (Génie Audio, St-Laurent, QC) to attenuate interference from outside noise.

This experimental setup is positioned under an operating microscope (OPMI 1-H, Zeiss) mechanically coupled to the sensor head of a laser Doppler vibrometer (Polytec HLV-1000). Glass micro beads (diameter 90-150 µm, Sigma) are placed at the points of measurement (Fig. 1) to increase reflectivity and thus improve the signal-to-noise ratio (SNR) of the measured signal. Measurements are acquired starting about 2 hours after the animal is sacrificed. The stimulus is a 128-ms sinusoidal sweep over the frequency range of 0.1 to 10 kHz. The displacements acquired are normalized to the SPL and averaged over 100 samples. The frequency responses below 0.15 kHz are not presented because of low SNR's at the lowest frequencies.

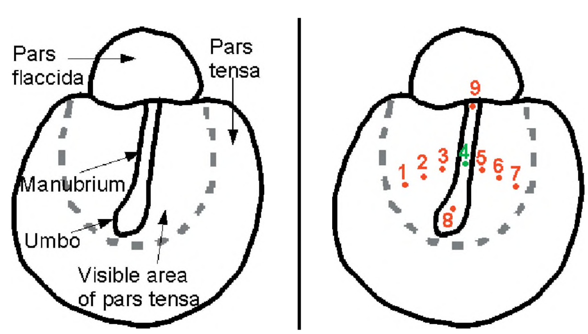

Fig. 1: LEFT: Schematic illustration of the tympanic membrane. Outlined in grey is the area of the pars tensa visible under the microscope. RIGHT: Locations of measurements.

3. RESULTS

3.1. Eardrum vibrations

A large number of measurements was performed on all five gerbils. We present here only the normalized displacements from one specimen, measured across the width of the visible portion of the pars tensa at points 1 to 7 (Fig. 2). The frequency response is flat at low frequencies, and features a peak at about 6.5 kHz and a larger peak at about 9.5 kHz. The frequency responses all have a similar shape over the whole frequency range. Displacements measured on the pars tensa are larger than those on the manubrium, with the magnitude increasing with the distance from the manubrium on both the anterior and posterior sides of the eardrum.

A comparison between symmetrically located points on each side of the manubrium reveals that displacements seem to be larger on the anterior side in all specimens studied. In some specimens, measurements were taken in both the inferior and superior portions of the pars tensa; displace¬ments were found to be larger in the inferior portion.

3.2. Manubrial vibrations

Normalized displacements recorded along the manubrium showed the same frequency-response shape as on the pars tensa. Manubrial displacements are generally largest at the umbo and decrease as the distance from the umbo to the point of measurement increases. In one gerbil, the shapes of the responses change beyond 6 kHz, and over a small range of frequencies (from 8 to 9 kHz) the manubrial displacements at a point superior to the umbo are actually larger than those at the umbo. These discrepancies may be attributable to significant temporal effects in that specimen.

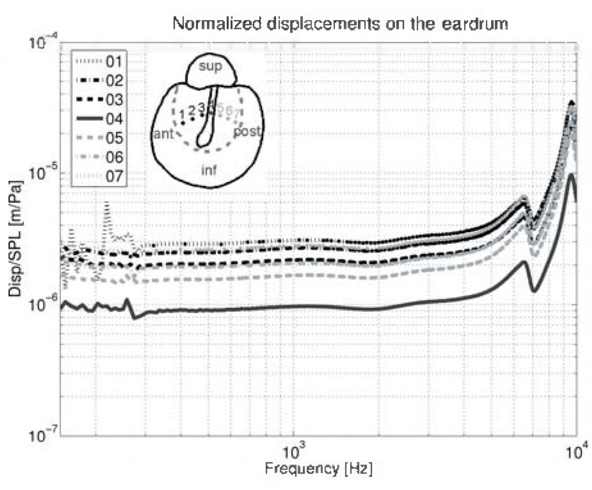

Fig. 2: Normalized displacements on the eardrum. Point 4 is on the manubrium (solid line, dark grey). Measurements on the anterior side of the pars tensa are shown in black, those on the posterior side are shown in light grey, using dashed, dot-dashed, and dotted lines as we move away from the manubrium.

4. CONCLUSION

This paper presents displacement measurements at multiple points on the gerbil eardrum. Spatial vibration patterns across the eardrum and along the manubrium are analyzed over the frequency range from 0.15 to 10 kHz. The similarity of the shapes of the frequency responses at all points of measurement indicates that the motion of the gerbil eardrum follows a simple pattern, with all points vibrating in phase. The complex patterns observed at a few kHz in other species (Tondorf & Khanna, 1972; Decraemer & Khanna, 1996; Rosowski et al., 2007) seem to occur beyond 10 kHz in our experiments. The manubrial displacements observed are consistent with the traditional concept of a simple rotation around a fixed axis extending from the anterior mallear ligament to the posterior incudal ligament. The manubrium appears to vibrate as a rigid body over at least most of the frequency range. Further measurements will be required in order to investigate the possible effects of manubrial bending and of shifting of the axis of rotation.

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MODELING AIRCRAFT CABIN NOISE WITH STATISTICAL ENERGY ANALYSIS (SEA)

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1. INTRODUCTION

Designing aircraft for lower passenger cabin noise and reduced weight is a considerable challenge that requires sophisticated prediction tools. Statistical Energy Analysis (SEA) is widely used in the aerospace industry to predict aircraft cabin interior noise in the mid-high frequency range. Bombardier Aerospace uses SEA as the primary tool to design optimized noise treatments at reduced weight. This paper is a summary of the work conducted by Bombardier to develop and validate SEA modeling methodologies for aircraft structures.

SEA is preferred over deterministic Finite Element (FE) methods to model the vibro-acoustic behaviour of aircraft structures[1]. Aircraft structures typically exhibit high modal densities in the mid-high frequency range, which are very sensitive to perturbations. Furthermore, the dominant noise sources in flight at cruise conditions are broadband, random, and appropriate for SEA modeling. Another advantage of SEA is that a path contribution analysis can be obtained from a solution, which is a valuable result that can be used to optimize the location of noise treatments.

2. SEA MODELING

The Statistical Energy Analysis (SEA) method[2] has been applied to model aircraft cabin noise in flight cruise conditions[3]. The aircraft modeling methodology has been developed from a progression of simple Transmission Loss (TL) models to more complex aircraft cabin noise models. Tests have been conducted to validate the SEA models. AutoSEA2 software is used for all SEA modeling.

2.1 Transmission Loss

Transmission loss of the fuselage cross-section has been modeled and validated with TL measurements conducted at the University of Sherbrooke. The TL model combines SEA and, independently, a transfer matrix approach to determine the insertion loss and absorption of the insulation blankets. The transfer matrix modeling is accomplished with Nova – a software code developed by the University of Sherbrooke and Mecanum Inc. – and models wave propagation through homogenous layers of solid, shells, fluid and porous media. The fuselage panel and trim are modeled as SEA subsystems – the ribbed panel property is used for the aluminum skin and frames, the sandwich or general laminate property is used for the trim panel.

2.2 Aircraft Cabin

The modeling technique developed and validated for TL provided the confidence to model the interior noise in a full aircraft with diffuse acoustic sources. SEA models of a green and completed aircraft were developed to predict the cabin average Sound-Pressure Level (SPL). These models consist of subsystems for the green aircraft structure, interior components, and acoustic cavities (cabin and below floor). Each subsystem must satisfy the SEA requirements – minimum 5 modes per band and a high modal overlap (>0.5). The models were validated from ground tests conducted with loudspeakers emitting pink noise surrounding the airplane in a hanger (a diffuse acoustic source was approximated).

After successful validation of the aircraft cabin model from ground test, the models were modified to predict the in-flight cabin average SPL at standard cruise condition. The diffuse acoustic field excitation was replaced with a Turbulent Boundary Layer (TBL) source, the dominant noise source for jets with fuselage aft mounted engines, in cruise flight condition. The Corcoss[4] and Efimtsov[5] models to estimate the modal power input to a structure excited by TBL were considered. Noise from the air supply and re-circulation in the cabin from the Environment Control System (ECS) was implemented as a direct user-defined power input source. Sound power levels were obtained from sound-intensity probe scans over the ECS registers. Noise from other systems such as pumps and fans are usually insignificant in cruise flight conditions. Structure-borne noise, originating from the fan and turbine tones through the engine mounts, is present but usually not significant in flight. Furthermore this excitation is lower in frequency, more deterministic and, hence, not well represented in an SEA model.

3. MODEL VALIDATION

Three TL configurations are considered – the bare fuselage panel (aluminum skin and frames), fuselage panel with insulation bags, and the fuselage panel with insulation and interior trim panel (double-wall system). The 1/3-octave band TL spectrum for each configuration is predicted and measured. Results for the double-wall system are shown in Figure 1.

Three aircraft cabin configurations are considered – green (bare fuselage structure, no insulation or interior), green with insulation blankets, completed aircraft (full interior installed). Cabin average 1/3-octave band SPL spectrum was predicted and measured from ground tests for the three configurations. Results for the completed aircraft case are shown in Figure 2.

The completed aircraft cabin model was modified to predict average SPL for in-flight cruise conditions. The TBL source model available in the software was used with default wavenumber and correlation decay coefficient constants (Corcoss model), and with wavenumber and correlation decay coefficient spectra calculated using the Efimtsov empirical equations[5]. Predicted cabin average SPL was compared to the average SPL from in-flight noise surveys on 5 aircraft with a similar interior. Average octave-band SPL spectra are shown in Figure 3, comparing SEA predictions (Corcoss and Efimtsov TBL models) with measurements.

4. DISCUSSION

Overall there was good agreement between SEA predictions and measurement for TL and cabin average SPL. The TL predictions correlate well with measurement for the fuselage panel with insulation and trim panel, yielding confidence in the modeling of noise transmission through the fuselage cross-section. In the aircraft cabin model with full interior, the SEA predictions compare well to the measurement, but under predict in the mid frequency range. This discrepancy is attributed to crude approximations in the modeling of the interior mounting and the damping of the trimmed fuselage. This could be improved with measured coupling loss factors for the interior mounts, and better damping models for the treated fuselage.

Good agreement in the cabin average SPL prediction vs. measurement for in-flight cruise condition was observed. The Efimtsov TBL model yielded better correlation to measurement. This model could also be improved with better coupling loss factors for the interior trim mounts and damping loss factors for the trimmed fuselage.

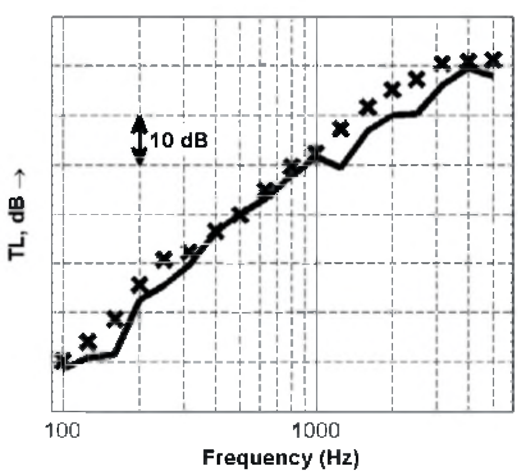

Figure 1. Third-octave band TL of the fuselage panel + insulation + trim panel. Measurement: X. SEA prediction: ▬

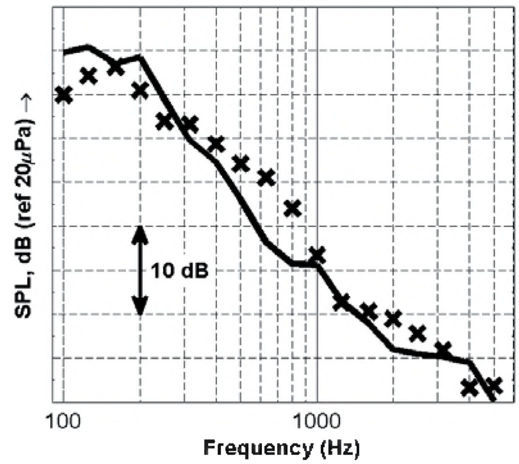

Figure 2. Cabin average 1/3-octave band SPL from ground test, diffuse acoustic exterior source. Measurement: X. SEA prediction: ▬

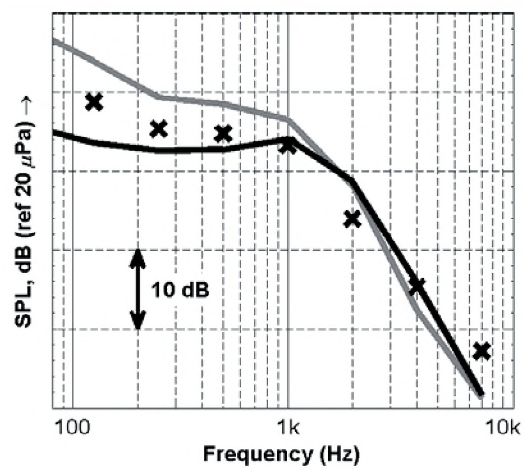

Figure 3. Cabin average octave-band SPL in flight cruise condition. Measurement: X. SEA prediction with Efimtsov TBL parameters: ▬ . Sea prediction with Corcoss TBL parameters: ▬

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VIKRUTHA PANCHAMA SCALES IN CARNATIC MUSIC (CONTAINING BOTH PERFECT FOURTH AND DIMINISHED FIFTH)

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ABSTRACT

The Carnatic classical music system which is prevalent in South India uses 12 semitones within an octave, as in Western classical music. There are seven syllables in the solfa system named S, R, G, M, P, D, and N (pronounced Sa, Ri, Ga, Ma, Pa, Da, and Ni, respectively). The first note S, and the perfect fifth P, are fixed in frequency in a melody scale according to convention. In any fundamental melody scale (parent raga), either the perfect fourth M1 or the augmented fourth M2 will be present exclusively. The second, third, sixth and the seventh notes can have three variations, some of which overlap as follows: R1 (minor second), R2 = G2 (major second), R3 = G2 (minor third), G3 (major third), D1 (minor sixth), D2 = N1 (major sixth), D3 = N2 (minor seventh), N3 (major seventh). With the above notation and using each solfa symbol S, R, G, M, P, D, N only once in the ascending order, traditionally 72 fundamental melody scales have been formed. Each one of them can have many derived scales excluding some notes, or using the notes in a convoluted fashion.

This paper presents 36 new fundamental melody scales for the first time, by using both perfect fourth (M1) and the augmented fourth (M2) in the same fundamental melody scale. Since the augmented fourth (M2) is also the diminished fifth, the perfect fifth is discarded and the unused solfa syllable P is attached to the diminished fifth. By varying the solfa syllables R, G, D, N as before will give 36 new fundamental melody scales. This will bring the total fundamental melody scales to 108.

INTRODUCTION

The fundamental melody scales in Carnatic music system were first propounded by Raamamaatya in his work *Svaramelakalanidhi* c. 1550 [1]. Later Venkatamakhi expounded in the 17th century in his work *Caturdandi Prakaasikaa* a new fundamental melocdy scale system known today as *melakarta* [2]. He had made some bold and controversial claims and defined 16 notes from the known 12 semitones in an octave at that time to arrive 72 fundamental melody scales. The double counting of R2 etc., his exclusive selection of the perfect fourth and the augmented fourth notes in a scale are arbitrary. However, today these 72 fundamental melody scales have gained acceptance, though to this day this system is being criticized.

Out of the 12 semitones in an octave, each fundamental melody scale (complete scale) shall consist of all the seven notes denoted by S, R, G, M, P, D, and N, pronounced as Sa, Ri, Ga, Ma, Pa, Da, and Ni. When two adjacent semitones are used in a melakarta scale, in order not to repeat the syllable in a given scale, the same semitone note is denoted with different syllables. For example, if the 2nd semitone R (R1, the minor second) is used in a scale, then the 3rd semitone is named as G (G1, the major second). However, if 3rd semitone is named R (R2, major second), the 4th semitone is named as G (G2, minor third). If the 4th semitone is named R (R3, minor third), then 5th semitone is named as G (G3, major third). Therefore the overlapping notes are R2=G1 (major second), R3=G2 (minor third), D2=N1 (major sixth), D3=N2 (minor seventh). As per agreed convention, P is held fixed without any gamaka (frequency modulations) given on that note. The 6th and 7th semitones are named as M1 and M2 (perfect fourth and augmented fourth). As per convention, a fundamental scale must necessarily have S and P, one of the M's, one each of the R's and G's, and one each of the D's and N's. Also, R must necessarily precede G and D must precede N. This gives $2 \times 6 \times 6 = 72$ melakarta ragas.

The notes Sa and Pa which do not admit variations are called suddha svaras or prakruti svaras or fixed notes. The suddha svara in modern south Indian Music refers to the lowest pitched notes in each note in the ascending scale. While the suddha S, suddha M (M1)and suddha P have retained their values from ancient times, the suddha R, suddha G, suddha D and suddha N have acquired different values at present.

Vikrutha Panchama Melakarta Scales

The note P (G in C major) is normally taken as fixed note. But this has not been always like that. In order to use both M1 (5th semitone) and M2 (7th semitone) in a new set of scales, the note P (8th semitone) is abandoned and the 7th semitone is named as P. This way all the seven syllables, S, R, G, M, P, D, and N are used in the set. Since the perfect fifth note is discarded, it cannot be used in the shruthi or the drone, and the perfect fourth should replace the perfect fifth in the shruthi. This scheme will generate 36 more ragas. The first six of these are listed in Table 1. The remaining 30 scales can be obtained by the following formula:

$$S, R_i, G_j, M_1, M_2 (= P), D_k, N_l$$

where i = 2, 3, 4, j = 3,4,5, k = 9, 10, 11, k = 10, 11, 12 and always j > i, and l> k.

CONCLUSIONS

A new set of 36 melakarta scales are proposed which consider both perfect fourth and diminished fifth in the same scale. In the process, the perfect fifth is discarded so as to retain the all seven notes S, R, G, M, P, D, and N only once in a scale. The addition of these 36 scales makes the total number of melakarta scales to be 108. The number of derived scales from these additional 36 scales is unlimited.

The total number of scales will now be 108 including the 72 propounded by Venkatamakhi. In Hinduism the number 108 has a special significance.

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Table 1. The first Six Vikrutha Panchama Melakarta Scales (Numbers refer to the semitone number)

1	2	3	6	7	9	10
1	2	3	6	7	9	11
1	2	3	6	7	9	12
1	2	3	6	7	10	11
1	2	3	6	7	10	12
1	2	3	6	7	11	12

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Canada Wide Science Fair

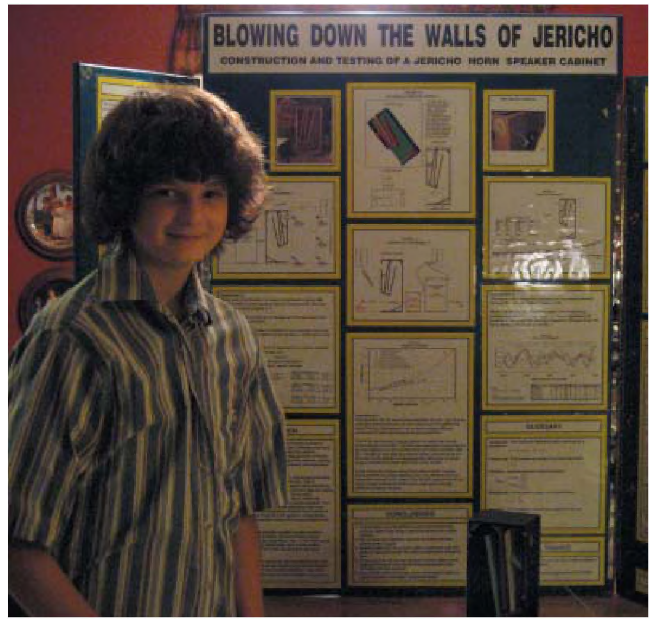
From File Reports

Luke Regier is the winner of this year's Special Award from the Canadian Acoustics Association for his project "Blowing Down the Walls of Jericho - Construction and Testing of a Horn Speaker Cabinet."

Luke Regier, 13 yrs old, is now attending St. Monica's School in Barrie Ontario as a grade 8 student. He has been involved in science fair and enjoy Science and Math. In Grade 6 his project was calculating the velocity of a hockey slap-shot using sound recording. The project won the Junior gold medal at the Simcoe County Regional fair. Luke was too young to be considered for participation at the Canada wide fair that year, but it gave him a good slap-shot that Spring and he scored a game winning goal with it.

His other interests and activities include snowboarding, hockey, and piano (currently at the grade 6 level, Celebration Series). He participates in piano recitals, exams, and occasionally competitions and plans to teach piano. Last summer he completed Bronze Medallion in swimming and plan to work up to life-guard.

The science fair award was presented in the Junior Physical Sciences Category, in which he also received Honorable Mention.



Luke Regier's full article is reproduced below.

Blowing Down the Walls of Jericho - Construction and Testing of a Horn Speaker Cabinet*

Luke Regier
St. Monica's School, Barrie, Ontario, Canada

Editor's Note: The submission by Steven Gasior was reformatted and edited to fit in to the Journal format.

1 INTRODUCTION

A Jericho Horn Speaker Cabinet (Jericho Cabinet) is a type of acoustic amplifier that has a number of chambers through which the sound travels. *The sound gets louder because of a process called resonation.* As sound waves travel through the horn, it gets in step with longer bass frequencies matching the full cycle of specific sound wave lengths in the widening chambers. *Vibrations in the cabinet walls match specific frequencies, amplifying them*. The Jericho Cabinet transforms sound to deeper tones lower in frequency. *This occurs because the sloping chamber walls of the Jericho only resonates certain frequencies; the higher frequencies are fewer as they get disrupted by the amplitude of the resonating frequency.* The Jericho Cabinet is not mass produced, and was constructed at home for testing from a design that appeared in the German engineering magazine "Klang and Ton" posted on a web site. The home made cabinet uses a store bought electrical speaker.

The perfromance characteristics of the Jericho speaker was evaluated throught an experiment. The purpose of this experiment was to construct, test, and explore the properties of a Jericho Cabinet, specifically:

1 - Does the Jericho cabinet resonate the bass sound frequencies?
2 - Differences in amplitude with 1 speaker against 2 in the Jericho Cabinet (Test 1).
3 - Energy use of a Jericho Cabinet with a 50 watt speaker, in comparison to a 200 watt bass amplifier speaker cabinet ? (Test 2).
4 - Explore the changes in the sound wave of a simple bass sample as it travels through the Jericho Cabinet (Test 3).

2 EXPERIMENTAL PROCEDURE

Build Jericho Cabinet using the specified dimensions and materials.

Test 1: wire 2 KOSS speakers into cabinet. Record the sound with microphone at 5 different locations, playing through 1 speaker and then 2 speakers.

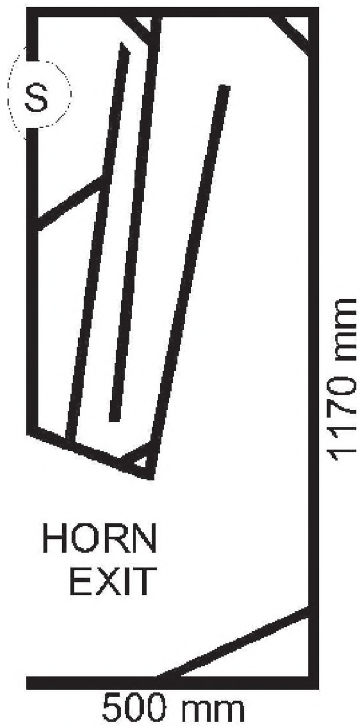


Figure 1. Jericho Speaker

Test 2: place microphone 5.0 m away from the Jericho Cabinet, and 5.0 m away from the Yorkville 200w Amplifier, recording sound at different volumes. Use UPM EM100™ energy meter to measure electrical power used by the Yorkville, then the Jericho Cabinet powered by smaller watt amplifiers, during each recording.

Test 3: drill holes into the side of the Jericho cabinet and record the sound in each chamber.

Graph and compare results from all three tests. An algorithm was used to determine the frequency of graphed waves by counting the number of intersections on the y axis.

3 RESULTS AND DISCUSSION

3.1 Construction and Testing

The Jericho Cabinet took 8 hours to build at a cost of approximately $165 including the speaker. The wood thickness in the website diagram was found to be incorrect. The thickness specified was 21 mm, but was actually 19 mm, a standard product thickness, found by adding up the overall dimensions. The finished speaker cabinet produced a clear, smooth tone at low to mid volumes; however, at high volumes it was observed that the speaker mounting rattled. The mounting bracket was of light plastic construction with a poor seal to the face of the cabinet. It was observed that the sound software records volumes as 1± decibels of sound pressure (dBsp). A formula is used to convert to decibels. The recordings were conducted either at suitable distance from the amplified speakers, or at low volumes.

3.2 Test Results

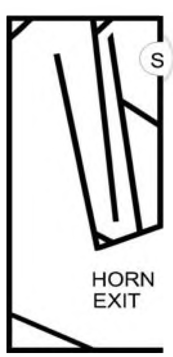
Test 1: There was a noticeable increase in Amplitude (volume dB) using 2 KOSS 3-watt speakers (Ks-3) compared to 1 Ks-3 at locations 1 and 2 (Figure 2).

The observed amplitudes at Location 2 were greater than the respective amplitudes observed at location 1, and much lower in frequency. Recordings at locations 3, 4, 5: were lower in volume dB, and the frequencies started to average out.

Test 2: The power use of various amplifiers to generated volume using the Jericho Cabinet was compared and the results are shown in Figure 3. Connected to the 30 watt Fender Amplifier (Fn-30), the Jericho used less electrical power at low volumes as a Yorkville 200 watt (Yk-200), illustrating it can be more energy efficient compared to high-watt mass-produced amplifiers. The Fn-30 did not have enough power to match the volume produced by the Yk-200. The test was repeated connecting the Jericho Cabinet to a 50 watt Marshall AVT Head Amplifier (Mr-50). The Mr-50 was able to produce higher volumes of sound than the Fn-30, but did not display better efficiency in power usage compared to either the Fn-30 or the Yk-200. It was observed volume output is directly related to power input and that electrical speakers are very efficient devices, using little energy. The Yk-200 could produce the most volume having the most power, and was as energy efficient at higher volumes.

Test 3: The sound wave frequency changed as the sound traveled through the Jericho Cabinet (See Figure 4). There

Figure 2 **- RESULTS OF EXPERIMENT 1 - COMPARING 1 AGAINST 2 SPEAKERS**



Location 1 (Speaker + 5 cm)

1 Speaker	359 Hz	31 dB
2 Speakers	304 Hz	36 dB

Location 2 (Horn + 5 cm)

1 Speaker	153 Hz	32 dB
2 Speakers	159 Hz	42 dB

Location 5 (Speaker + 1m)

1 Speaker	257 Hz	26 dB
2 Speakers	238 Hz	26 dB

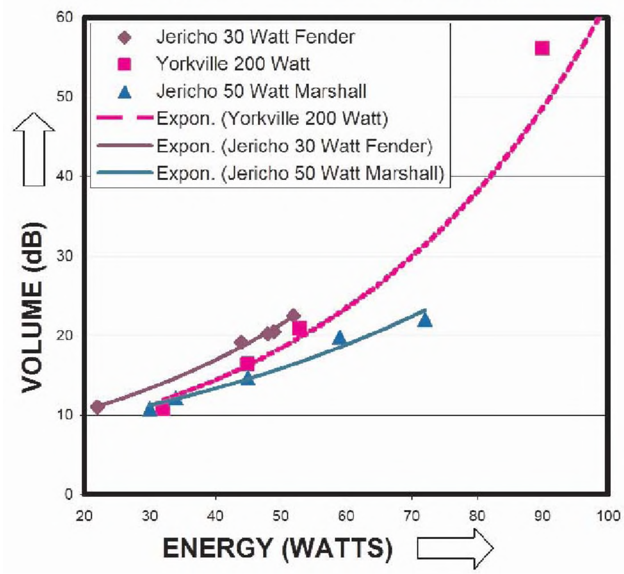
Location 3 (Midpoint + 1m)

1 Speaker	178 Hz	26 dB
2 Speakers	192 Hz	26 dB

Location 4 (Horn + 1m)

1 Speaker	167 Hz	26 dB
2 Speakers	162 Hz	27 dB

Figure 3 - ENERGY vs VOLUME



is a noticeable and measurable lower frequency produced in each chamber. From location 0 (Speaker), to location 4 (horn exit) the average frequency changed from 287 Hz to 88 Hz, a decrease of 199 Hz.

3.3 Discussion

The most striking observation noted during the process of building the Jericho cabinet was its shape. Starting from the top where the sound from the speaker enters, the cabinet gets larger in size. This enlarging pattern continues through the fourth chamber at the base of the cabinet, making a horn shape. This is how the Jericho cabinet resonates bass sounds. The distance the sound travels is 3.37m, taking approximately 0.01 seconds at the speed of sound of 344 m/s. This is approximately the wavelength of the frequencies produced by the speaker, meaning the sound exiting the horn lags the sound of the speaker by 1 or 2 wavelengths.

It was observed that there was a slight increase in amplitude between having 1 and 2 speakers in the Jericho (Test 1). This is because with 2 speakers, the small additional amount of power used to drive the 2nd speaker doubles the vibration of air. The two sources of sound in the speaker compartment also provide some resonation where the waves combine from both speakers.

The Yorkville 200 watt amplifier speaker produced better power to volume ratio at higher volumes because larger speakers can move larger quantities of air. It was discovered that the Marshall design technology uses a Tube system, producing heat as well as sound, causing it to use more energy.

4. Conclusions

i. The speaker could be bolted directly to the face of the cabinet, rather than using a mounting bracket to reduce rattling.
ii. The Jericho Horn Speaker Cabinet resonates the bass frequencies of sound
iii. Speaker Cabinets can provide higher amplitudes with the same of amount of power by using two speakers instead of one.
iv. At low volumes, the 50 watt speaker Jericho Cabinet took less power to give it the same volume compared to the Yorkville 200 watt speaker.
v. The Jericho Cabinet changes sound traveling through it to lower frequency and higher amplitude waves.

Fewer speaker cabinets are needed as the Jericho Cabinet provides a source of bass sound. There is a stereo effect caused by time lag between the bass frequency and the originating source of sound at the speaker, and separation between the speaker and horn. This was a practical science project that can be enjoyed for many years.

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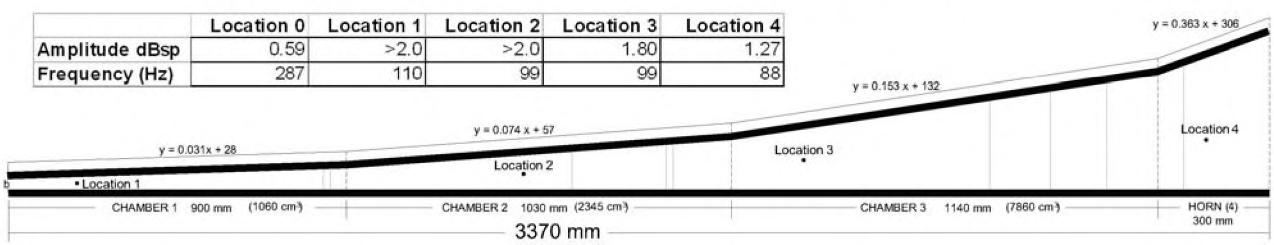
Figure 4 DIAGRAM AND RESULTS TEST 3
PROFILE OF HORN & CHANGE IN SOUND THROUGH CHAMBERS

	Location 0	Location 1	Location 2	Location 3	Location 4
Amplitude dBsp	0.59	>2.0	>2.0	1.80	1.27
Frequency (Hz)	287	110	99	99	88



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Diagnostic Ultrasound: Imaging and Blood Flow Measurements, By K. Kirk Shung CRC Press, 2005, List price: $109.95 USD (hardcover), 232 pp., ISBN: 0824740963

A pioneer in ultrasound research for over 30 years, Dr. K. Kirk Shung has recently authored a book on diagnostic ultrasound. His motivation was in part, as he states in his book, that "not a single book in ultrasound imaging on the market today contained sufficient technical material suitable for adaption as a textbook at the college or graduate school level, although many excellent books for clinician's technologists were in print". In that spirit, Dr. Shung wrote this book with the senior undergraduate or junior graduate student that requires an introductory course on ultrasound in mind. It should be noted that other books have also been recently published with this intended audience (e.g. Diagnostic Ultrasound Imaging: Inside Out, by Thomas Szabo, Elsevier Academic Press, 2004).

The book was based on notes for a graduate course on ultrasound imaging that the author has been teaching for the last 15 years at the Department of Bioengineering at Pennsylvania State University and the University of Southern California. In general, it does not delve into great detail in any of the topics presented, but tries to strike a balance between illustrating the necessary physics and engineering concepts to understand the formation of images and the estimation of flow using ultrasound.

After a very brief introduction to ultrasound in Chapter 1, Chapter 2 covers the fundamentals of ultrasound propagation. The stress strain relationships are covered and this material builds up to the acoustic wave equation, with brief coverage of topics such as intensity, impedance and radiation force. The author delves into more detail on the topics of attenuation, absorption and scattering. It is nice to see included a brief treatment of the non-linearity parameter. The Chapter ends with a description of the Doppler effect. Given the breadth of material covered, the Chapter is rather succinct and spartan, but adequate as introductory text. It could have been better referenced so that the reader seeking detail behind some of the material presented could consult these references.

Chapters 3 and 4 deal with ultrasound transducers/arrays and gray scale ultrasonic imaging in general. As transducer technology is one of the areas of specialization of the author, this is a well covered topic in the book, with judicious use of schematics and figures and coverage of topics such as transducer models, matching (mechanical and electrical), beam profiles and array theory and design. It is also well referenced. After the chapter on transducer technology, Chapter 4 introduces the components and processing of common ultrasonic imaging systems. The different imaging modes are introduced and several block diagrams of imaging systems are presented. The resolution of imaging systems is discussed, and issues such as beam forming, image quality (speckle, point spread function, spatial and contrast resolution) as well as other types of imaging (coded excitation, compound, synthetic aperture) are introduced. Again, due to the short description of several of the topics, a more comprehensive bibliography would have been beneficial.

Chapters 5 and 6 deal with the measurement of flow with ultrasound. The author discusses in Chapter 5 continuous wave and pulsed wave Doppler systems and has a fine description of the basis of such measurements, with a good level of analysis included. Chapter 5 ends with a description of the potential problems in Doppler measurement. Chapter 6 introduces flow and displacement imaging, first through the description of color Doppler flow systems and then elasticity imaging. This Chapter ends with a section on B-Flow imaging (which uses coded excitation techniques mentioned prior to equalize blood and tissue signals).

Dr. Shung presents contrast media and harmonic imaging in Chapter 7. Again, a nice balance is reached between depth and breath, as there is sufficient detail and discussion on bubble scattering and dynamics (including discussions of bubble encapsulation, bubble distribution and non-linear interactions of bubbles with ultrasound). Solutions to the appropriate equations are presented, even though a greater emphasis could have been placed to applications in this new and exciting field. The Chapter closes with a description of harmonic imaging.

In Chapters 8 and 9 intracavity and high frequency ultrasound, as well as multidimensional imaging are presented. Here the topics are glossed over, with greater emphasis on the technology and applications rather than the salient differences when imaging using these frequencies. Two dimensional arrays are discussed in Chapter 9, in which cMUT technology is also presented. The Chapter closes with a description of three dimensional imaging.

Very brief descriptions of bioeffects are presented in Chapter 10. Again, the basics are discussed, and some important tables and figures from the AIUM (American Institute of Ultrasound in Medicine) and AIUM/NEMA recommendations are used. The final Chapter focuses on methods that are used for measuring the speed of sound, attenuation absorption and scattering. As indicated by the author in the preface, this last chapter is optional in a semester course, but a useful addition for students and investigators planning to perform such ultrasonic experiments.

Overall, this is a well organized and illustrated book that fills a gap in the ultrasonic literature. It has enough material to be used in a one semester course on ultrasound imaging, however almost certainly other texts need to be consulted if any of the topics presented are to be studied in depth. I have found myself consulting the book on occasion in the preparation of lectures, and using it as a reference sporadically.

Dr. Michael Kolios

Department of Physics, Ryerson University, Toronto

Diagnostic Ultrasound Imaging: Inside Out
By Thomas L. Szabo
Elsevier Academic Press, 2004
List price: $94.95 USD (hardcover)
576 pp., ISBN: 0126801452

As a graduate student in medical physics I often encounter textbooks on a given imaging modality providing a comprehensive look at the essential physics with outdated examples, or excellent reviews of current applications with little to offer on the basic theory behind the modality. It was rather refreshing to come across this text by Thomas L. Szabo which covers the essential introductory physics and signal processing concepts of ultrasound as well as a breadth of advanced topics, including findings from the latest ultrasound research, all in a neat 540-page package.

Dr. Szabo is a Research Professor in the departments of Biomedical Engineering and Aerospace & Mechanical Engineering at Boston University. He is a fellow of the Acoustical Society of America and spent nearly 20 years in ultrasound research and development at Hewlett Packard (later Agilent).

This book has 15 chapters: 1) Introduction; 2) Overview; 3) Acoustic Wave Propagation; 4) Attenuation; 5) Transducers; 6) Beamforming; 7) Array Beamforming; 8) Wave Scattering and Imaging; 9) Scattering from Tissue and Tissue Characterization; 10) Imaging Systems and Applications; 11) Doppler Modes; 12) Nonlinear Acoustics and Imaging; 13) Ultrasonic Exposimetry and Acoustic Measurements; 14) Ultrasound Contrast Agents and 15) Ultrasound-induced Bioeffects.

Chapter 1 gives a historical overview of ultrasound, from the beginnings of sonar to current technologies and provides the reader with a comparison between existing imaging modalities. For those with little background in signal processing, chapter 2 introduces the Fourier Transform and signal processing concepts in the time and frequency domains using a building block approach that is carried through to the rest of the book. Additional information on Fourier Transforms and their applications are included as an appendix. Chapters 3 through 8, as well as chapter 10 comprise, what I consider, the “core” of the book, covering the essential physics, signal processing and application of ultrasound. The remainder of the book covers a variety of advanced topics. These range from imaging techniques such as Doppler ultrasound and color flow imaging, harmonic imaging and microbubble contrast agents to the use of ultrasound for tissue and transducer characterization and, finally, a chapter on the bioeffects of ultrasound as they relate to safety and to therapeutic applications.

Though the basic theoretical building blocks are covered, making this book accessible to the complete beginner reader in ultrasound, a background in mathematics and physics, specifically an understanding of calculus, complex numbers and some knowledge of electric circuits, is essential to fully benefit from this text. Graduate students in medical physics and biomedical engineering will find this book most useful as it provides a very comprehensive overview of ultrasound imaging physics with the option to progress to more advanced topics. Nevertheless, this book will also serve as a great reference for researchers, engineers and physicists well versed in ultrasound as its coverage of advanced topics is not trivial and includes the work of hundreds of contributors to the field.

Golnaz Farhat
Department of Medical Biophysics
University of Toronto, Toronto

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March 30 - April 01. SAE-Brazil Noise and Vibration Conference-NVH. Florianopolis, SC, Brazil. Web: www.saebrasil.org.br/eventos/secao_parana_sc/nvh2008/site/

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08-11 avril. Oceans '08. Kobe, Japan. Web: www.oceans08mtsieeekobe-technoocean08.org/index.cfm

10-11 avril. Institute of Acoustics (UK) Spring Conference. Reading, UK. Web: www.ioa.org.uk/viewupcoming.asp

17-18 avril. Swiss Acoustical Society Spring Meeting. Bellinzona (Tessin), Switzerland. Web: www.sga-ssa.ch

12-15 mai. 10th Spring School on Acousto-optics and Applications. Sopot, Poland. Web: http://univ.gda.pl/~school

29 juin - 04 juillet: Joint Meeting d'European Acoustical Association, Acoustical Society d'America, et Acoustical Society du France. Paris, France. Web: www.sfa.asso.fr/en/index.htm

06-10 juillet. 15th International Congress on Sound and Vibration. Daejeon, Korea. Web: www.icsv15.org

7-10 juillet: 18th International Symposium sur Nonlinear Acoustics (ISNA18). Stockholm, Sweden. E-mail: benflo@mech.kth.se

21-25 juillet. 9th International Congress on Noise as a Public Health Problem. Mashantucket, CT, USA. Web: www.icben.org

27-30 juin. Noise-Con 2008. Dearborn, MI, USA.

27-31 juillet. 10th Mechanics of Hearing Workshop. Keele University, UK. Web: www.mechanicsofhearing.com

28 juillet - 1 août: 9th International Congress sur Noise as a Public Health Problem. Mashantucket, Pequot Tribal Nation, (CT, USA). Web: www.icben.org

25-29 août: 10th International Conference on Music Perception and Cognition. Sapporo, Japan. Web: http://icmpc10.typepad.jp

08-12 septembre: International Symposium on Underwater Reverberation and Clutter. Lerici, Italy. Web: http://isurc2008.org

10-12 September. Autumn Meeting of the Acoustical Society of Japan. Fukuoka, Japan. Web: www.asj.gr.jp/index-en.html

15-17 September: International Conference on Noise and Vibration Engineering (ISMA2008). Leuven, Belgium. Web: www.isma-isaac.be

16-18 September: Underwater Noise Measurement. Southampton, UK. Web: www.ioa.org.uk/viewupcoming.asp

22-26 September: Interspeech 2008 - 10th ICSLP, Brisbane, Austrailia. Web: wwwinterspeech2008.org

23-25 September. Underwater Noise Measurement. Southampton, U.K. Web: www.ioa.org.uk/viewupcoming.asp

21-23 October. 13th Conference on Low Frequency Noise and Vibration. Tokyo, Japan. Web: www.lowfrequency2008.org

21-24 October. Acustica 2008. Coimbra, Portugal. Web: www.spacustica.pt

26-29 October: Internoise 2008, Shanghai, China. Web: www.internoise2008.org

01-05 November. IEEE International Ultrasonic Symposium. Beijing, China. Web: www.ieee-uffa.org/ulmain.asp?page=symposia

24-26 November. Australian Acoustical Society National Conference. Victoria, Australia. Web: www.acoustics.asn.au

2009

19-24 April. International Conference on Acoustics, Speech, and Signal Processing. Taipei, R.O.C. Web: icassp09.com

23-26 August: Internoise 2009, Ottawa, Canada.

23-27 August: International Confress on Acoustics 2010. Sydney, Australia. Web: www.acoustics.asn.au

06-10 September: Interspeech 2009. Brighton, UK. Web: www.interspeech2009.org

2010

19-24 March. International Conference on Acoustics, Speech, and Signal Processing. Dallas, TX, USA. Web: icassp2010.org

23-27 August: International Confress on Acoustics 2010. Sydney, Australia. Web: www.acoustics.asn.au

26-30 September: Interspeech 2010. Makuhari, Japan. Web: www.interspeech2010.org

10-12 septembre. Autumn Meeting of the Acoustical Society of Japan. Fukuoka, Japan. Web: www.asj.gr.jp/index-en.html

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NEWS

We want to hear from you! If you have any news items related to the Canadian Acoustical Association, please send them. Job promotions, recognition of service, interesting projects, recent research, etc. are what make this section interesting.

Canadian Acoustical Association

Minutes of the Board of Directors Meeting
9 October 2007
Montreal, Québec

Present: Stan Dosso (chair), Nicole Collison, David Quirt, Rich Peppin, Christian Giguère, Ramani Ramakrishnan, John Bradley, Clair Wakefield

Regrets: Alberto Behar, Dalila Giusti, Tim Kelsall, Geoff Morrison, Vijay Parsa

The meeting was called to order at 7:05 p.m. Minutes of Board of Directors meeting on 12 May 2007 were approved as published in Canadian Acoustics (June 2007 issue). *(Moved R. Peppin, second C. Wakefield, carried).*

President's Report

Stan Dosso reported that there have been no major problems in the affairs of the Association. He emphasized the need to continue recent progress on updating our website to provide more services, to move to online publication of Canadian Acoustics, and to enhance processes to support the Treasurer and Secretary. He noted that this is his last meeting as Chair, and thanked the other members of the Board for continuing support through his four years as president. *(R. Peppin moved acceptance of report, N. Collison second, carried)*

Secretary's Report

David Quirt reported that memberships are quite steady; last year's total was 380 on 4 Oct. and this year's total on that date is 370.

Mailing list (20 April)	Canada	USA	Other	Change
Member	209	19	9	**+13**
Student	52	1	6	**-19**
Sustaining	41	3	1	**–2**
Direct	3	2	–	**– 2**
Indirect	10	9	4	**+2**
		Total = 370		**(Down 10)**

Payments by VISA remain just above 40%, and online payment has still not been implemented. Updating of membership address data including e-mail was continued in the renewal process; we have working e-mail addresses for 70% of the members.

Secretarial operating costs for FY2006/07 were $1290 (slightly lower than last year), mainly for mailing costs and postal box rentals. A budget allocation of $1200 for next year is requested.

Issues of Noise News International were mailed as they arrived, to 49 members who requested this option, and shipment from the publisher in the USA has improved from the former pattern of at least 6 months late.

With respect to CAA communications, David noted that forms were received and processed for annual filing with Corporations Canada, and memberships for I-INCE and ICA. Overall, routine business of CAA is proceeding without major problems. *(R. Peppin moved acceptance of report, N. Collison second, carried)*

Treasurer's Report

The Treasurer, Dalila Giusti, was unable to attend, but submitted a report and a preliminary financial statement, for the fiscal year.

Most expenses were essentially as budgeted, and the conference in Halifax made a comfortable profit. It is a typical year in terms of cash flow, except that advertising revenue is down (due to invoicing and payment delays) and interest on our capital fund was only $3300 (which will not cover the anticipated $6250 for prizes in October 2007). This is not a critical problem, since we have a substantial cash balance.

Implementation of a new investment strategy for the capital fund is proceeding as authorized at the Board meeting in May. This should raise the annual income from the capital fund to approximately $9000 in future years.

The Board discussed immediate steps to deal with collection of outstanding advertising fees for the journal.

Stan has organized an ad hoc group (Dalila Giusti, Dave Quirt, and Geoff Morrison) to plan and implement online payment via the website, using a service provider for secure transactions. This is proceeding very slowly, but they will present a detailed costing proposal for e-mail approval by the Board as soon as feasible.

Dalila proposed that we shift our financial year to end on 30 June, so we could have audited reports available for the AGM in October. This was discussed – it is a two-year process to amend our bylaws, and the benefit was questioned. This topic will be discussed at the next Board meeting in spring of 2008.

Dalila proposed a fee increase, to be presented to the AGM at the October meeting, and the Board agreed, after some discussion. A budget for 2007/08 was also presented; the only change suggested was an amendment to allot $1200 for secretarial expenses.

The Treasurer's report and the proposed budget (as amended) were accepted.
(Moved R. Peppin, second S. Dosso, carried.)

Editor's Report

The Editor, Ramani Ramakrishnan, presented a brief report on issues related to content and publication process for *Canadian Acoustics*.

A special issue of Canadian Acoustics featuring papers on medical ultrasound was published in June 2007. Another special issue featuring papers from a conference is planned for March 2008.

Ramani is on sabbatical (from September 2007) but expects that operation of the journal will proceed normally, since most stages of review and publication are handled via email.

The major issue of discussion was the continuing initiative to establish online publication of the journal. A project to move small Canadian technical journals to online publication has been financed through a university grant. The project includes conversion of old issues and mounting of old and new issues on a server operated by University of Toronto. The system includes password access capabilities, but older issues could be made freely accessible. Our publications would also be included in citation listings and be readily accessible to search engines. Trial issues will be mounted by the end of 2007, and passwords will be distributed to Members as part of the annual receipt/invoice process. At this stage, there is no direct financial cost to our Association.

(Acceptance of report moved R. Peppin, second N. Collison, carried.)

CAA Website

Stan Dosso led the discussion on the CAA website, on behalf of Geoff Morrison who has recently assumed the role of Webmaster but could not attend.

The key issue is implementing online payment by credit card for both memberships and conference registration. The Board wants to move ahead rapidly with implementing such a system, as discussed above in the Treasurer's Report. Once detailed costs have been established, and authorized by a ballot of the Board, a new payment system will be implemented - hopefully in time for this year's membership renewal process.

CAA Conferences – Past, Present & Future

<u>CAA-2006 (Halifax)</u>: Nicole Collison, who was conference Chair, submitted a thick report with several appendices useful for organizing future meetings. Total attendance was 100, with a wide variety of papers, well-attended plenary sessions, 9 exhibits, and outstanding social events. Financially, net income was $4117 including $620 for new memberships. The Board expressed their thanks for a job well done by the Halifax team.

<u>CAA-2007 (Montreal):</u> A preliminary report by the Chair, Rama Bhat indicated all aspects of the conference are proceeding well. Conference sessions are in the Engineering and Visual Arts Building at Concordia. There are an exceptionally high number of student presentations, and several organized sessions. This meeting has many

variations on our traditional approach to meals and events included in the registration fee.

The facilities at Concordia are quite different from those in a hotel, and this led to a general discussion by the Board of how we should mesh the exhibits with sessions at future meetings. It was agreed that Rich Peppin should pursue this with the organizers for the next meeting.

CAA-2008 (Vancouver): A team to organize the conference has been confirmed, with Murray Hodgson as Chair. At the time of the Board meeting, arrangements were not final. See the first announcement of conference details in this issue of *Canadian Acoustics*.

CAA-2009 (???): Suggested sites were the Toronto area (perhaps Niagara?), or Calgary area (perhaps Banff?), but no volunteers yet.

InterNoise 2009 (Ottawa) is a joint venture of CAA and INCE-USA. A report was received from Trevor Nightingale, the conference Chair. Key arrangements have been confirmed; the conference will be held in the Westin Hotel in downtown Ottawa on 23-26 August. Press releases and the first call for papers are planned through the coming year.

ICA 2013 (Montreal) is a joint venture of CAA and ASA. A report was received from Mike Stinson, the conference Chair. The ICA has accepted the Canadian bid for the conference (over strong competition from Brazil). Key arrangements have been confirmed; it will be held in the Palais des congrès in Montreal on 2-7 June 2013.

Awards

Christian Giguère presented a detailed report summarizing decisions by the coordinators for all CAA awards. There were applications for all awards except the Directors' Prize for student papers in *Canadian Acoustics*, and the winners have been selected. Winners were announced at the banquet on 11 October, and in this issue of *Canadian Acoustics*.

A master list of award winners is ready and will be added to the CAA website, together with minor updates of prize details. It was agreed that details about prizes in the CAA Operations Manual should be deleted, to avoid conflicts with the Awards pages on the website (intended as the primary reference on Awards). The Board thanked Christian and his Coordinators.

Nominations

John Bradley presented a list of nominees for positions on the Board and Executive. Stan Dosso has decided not to seek re-election, after four years as our President. Four Directors are at the end of their terms; two of these Directors (Alberto Behar and Vijay Parsa) have agreed to stand for a one-year extension of their terms. The Board endorsed the suggested nominees for all positions. (Election followed at the Annual General Meeting, as required by CAA bylaws; see AGM report.) The Board thanked Stan and the outgoing Directors (Christian Giguère and Anita Lewis) for their years of contributions to the Association.

Other Business

As planned, David presented a preliminary set of options for new membership categories and fees, and this induced lengthy discussion. Terms for Life Member will be developed and discussed at a future meeting. Proposals for Retired Member and Fellow were discussed, and consensus was established on the basic rules and process for such extensions. It was agreed that these should be integrated with proposed fee changes, for presentation to the Annual General Meeting, following our tradition of approving all such changes at the AGM.

Adjournment

Meeting adjourned at 10:13 p.m. *(Moved R. Ramakrishnan, second N. Collison, carried.)*

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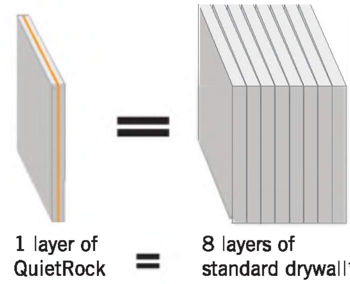

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STC	49-68	46-49	51-72	55	50-58	52-74	56-80
Thickness	1/2”	1/2”	5/8”	5/8”	5/8”	5/8”	1-3/8”
Weight	2.2 lbs/sq ft	2.3 lbs/sq ft	2.7 lbs/sq ft	2.7 lbs/sq ft	3.9 lbs/sq ft	2.8 lbs/sq ft	5.4 lbs/sq ft
Fire Rating	Not rated	Not rated	1 hour	1 hour	1 hour	1 hour	2 hours (estimated)

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Product	QW-630 Serenity	QW-631 Solitude
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STC	51-62	58*
Thickness	5/8”	1 1/8”
Weight	2.3 lbs/sq ft	3.8 lbs/sq ft
Fire Rating	Not Rated	1 hour

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Canadian Acoustical Association

Minutes of Annual General Meeting

Concordia University, Montreal
11 October 2007

Call to Order

President Stan Dosso called the meeting to order at 6:00 p.m. with 25 members present. Minutes of the previous Annual General Meeting on 12 October 2006 in Halifax were approved as printed in the December 2006 issue of Canadian Acoustics. *(Moved by R. Peppin, seconded Nicole Collison, carried)*

President's Report

Stan Dosso briefly summarized the report he presented at the Board meeting on 9 October, noting that this is his last AGM as President. He emphasized that the society is in good condition, and he thanked all those who have made contributions to our activities.

Secretary's Report

David Quirt presented a brief overview of membership and operational activity. All activities are proceeding smoothly. CAA membership and subscriptions have dropped marginally, from 380 to 370 at the end of September. An itemized account of the administrative budget of $1290 for mailing and database expenses was presented to the Board of Directors.

Responding to a debate at the previous AGM, the Secretary presented a set of proposals for membership options. There was consensus on the proposed category of Retired Members, but some reservations about the proposal for Fellows. The Board will finalize rules for these categories and establish an Awards subcommittee responsible for the latter, and will publish the proposals in *Canadian Acoustics* to facilitate an informed vote at the next AGM.

(Acceptance of the report moved by R. Ramakrishnan, seconded M. Cheesman carried.)

Treasurer's Report

In the absence of the Treasurer, Dalila Giusti, David Quirt presented an overview of her report on CAA finances. CAA is in good financial shape, with total assets of $227,299 at fiscal year end (before audit). Total assets declined slightly this year, due to awarding almost all prizes in a year when interest on our capital investments and other revenue were low (due to delays in collecting advertising revenue and higher-than average costs in some other expenses such as publishing costs). A change to increase the yield on our investments is underway, with the goal of fully covering the cost of awards.

This year, a small budget deficit is predicted if the conference breaks even and other income and expenses remain the same as last year. In fact, increased website and service costs are expected as we implement online payment. The Board therefore proposed a $5 increase in fees for Students (to $25) and for Members and Subscribers (to $65) this year, with other rates remaining unchanged.
(Acceptance of proposed fee structure moved by H. Forrester, seconded R. Peppin, carried.)

Editor's Report

Ramani Ramakrishnan gave the Editor's report. *Canadian Acoustics* production has proceeded smoothly throughout the year, with all issues printed on schedule. A special conference proceedings issue on medical ultrasound was published in June 2007. The process for paper submission/review/publication is proceeding smoothly. Ramani also outlined the project to establish online publication of *Canadian Acoustics* (more detail in minutes of the Board of Directors meeting).

Award Coordinator's Report

Christian Giguère acknowledged the continuing hard work of CAA awards coordinators, and reported the awards to be presented this year.

This year CAA is awarding all prizes except the Directors' Award for best student paper in *Canadian Acoustics*. In addition, there are the student paper awards for presentations at the conference. (See separate announcement in this issue for names of recipients.)

Past and Future Meetings

Reports were presented on the past, present and future annual meetings:

Halifax (October 2006): Nicole Collison reported for the Halifax team. The attendance of 100 generated a financial surplus of $4117 and social events such as the pub evening were outstanding. The organized sessions covered a wide range of topics, with 2 well-attended plenary talks and 75 papers (58 published in *Canadian Acoustics*). Online submission of abstracts and papers was implemented at this meeting, and was a huge success.

Montreal (October 2007): Rama Bhat presented a preliminary overview of the 2007 conference. Attendance is expected to be over 120, and the meeting should break even. The exceptionally large number of student papers was noted.

Vancouver (October 2008): An organizing team led by Murray Hodgson is proceeding with arrangements. Details will be on the website and in upcoming issues of *Canadian Acoustics*.

There was applause to express our thanks to all organizers. This was followed by brief reports on two major international conferences that are sponsored by CAA and will be held in Canada:

InterNoise 2009 (23-26 August at the Westin Hotel in Ottawa) is a joint venture of CAA and INCE-USA.

ICA 2013 (2-7 June at Palais des congrès in Montreal) is a joint venture of CAA and ASA.

CAA Website

Stan Dosso noted the excellent quality of the CAA website and the many improvements such as the online submission system for papers that were implemented by Dave Stredulinsky over his many years as Webmaster.

Stan reported that Geoff Morrison has now succeeded Dave as Webmaster.

There are plans for continuing improvements, such as implementation of an online payment capability for membership and other transactions, and online access to *Canadian Acoustics*.

Nominations and Election

CAA corporate bylaws require that we elect the Executive and Directors each year.

This year, Stan Dosso chose not to seek re-election after 4 years as President, and two Directors completed their terms on the Board—Christian Giguère and Anita Lewis. There was applause to recognize their contributions.

The Past President, John Bradley, presented the nominations and managed the election process. In each case, he read the name of the nominee, and then asked if there were other nominees from the floor.

- Christian Giguère for President
- Dalila Giusti for Treasurer
- David Quirt for Executive Secretary
- Ramani Ramakrishnan for Editor
- Finally, John presented names of proposed continuing Directors (Nicole Collison, Alberto Behar, Rich Peppin, Vijay Parsa, Tim Kelsall, Clair Wakefield) and new Directors (Frank Russo and Jérémie Voix).

In each case, there were no other nominations from the floor, so these nominees were declared elected by acclamation.

After completion of the election process, Stan Dosso noted that this completed John Bradley's duties as Past President, and proposed a special vote of thanks for John's 10 years as President and Past President. There was enthusiastic applause.

Adjournment

Adjournment was proposed by Harold Forester and seconded by Clair Wakefield. Carried. Meeting adjourned at 6:50 p.m.

Canadian Acoustical Association
Association canadienne d'acoustique

2007 PRIZE WINNERS / RÉCIPIENDAIRES 2007

SHAW POSTDOCTORAL PRIZE IN ACOUSTICS /
PRIX POST-DOCTORAL SHAW EN ACOUSTIQUE

Hui Qun Deng, INRS-EMT (Montréal)
"Speech Feature Recognition and Transmission"

BELL GRADUATE STUDENT PRIZE IN SPEECH COMMUNICATION AND HEARING /
PRIX ÉTUDIANT BELL EN COMMUNICATION VERBALE ET AUDITION

Gurjit Singh, University of Toronto (Mississauga)
"*Cognitive and Auditory Factors Underlying Auditory Spatial Attention*"

FESSENDEN GRADUATE STUDENT PRIZE IN UNDERWATER ACOUSTICS /
PRIX ÉTUDIANT FESSENDEN EN ACOUSTIQUE SOUS-MARINE

Michael G. Morley, University of Victoria
"*Geoacoustic inversion using a ship-noise source*"

ECKEL GRADUATE STUDENT PRIZE IN NOISE CONTROL /
PRIX ÉTUDIANT ECKEL EN CONTRÔLE DU BRUIT

Marc-André Gaudreau, École de Technologie Supérieure (Montréal)
"Mesure de l'efficacité des protecteurs auditifs en continu au cours d'une journée de travail"

RAYMOND HÉTU UNDERGRADUATE PRIZE IN ACOUSTICS /
PRIX ÉTUDIANT RAYMOND HÉTU EN ACOUSTIQUE

Huiwen Goy, University of Toronto (Mississauga)
"Effect of within and between-talker variability on word identification in noise in older and younger adults"

CANADA-WIDE SCIENCE FAIR AWARD / PRIX EXPO-SCIENCES PANCANADIENNE

Luke Regier, St. Monica's E.S. (Simcoe County, Ontario)
"Blowing Down the Walls of Jericho"

DIRECTORS' AWARDS / PRIX DES DIRECTEURS

Individual Member / Membre Individuel:

Stan Dosso, University of Victoria
"Array Element Localization Accuracy and Survey Design"
Canadian Acoustics 34(4): 3-13

STUDENT PRESENTATION AWARDS / PRIX POUR COMMUNICATIONS ÉTUDIANTES
CONCORDIA UNIVERSITY, MONTRÉAL (QC), OCTOBER 9-12, 2007

Marc-André Gaudreau, École de Technologie Supérieure (Montréal)
"Variabilité de l'atténuation des protecteurs auditifs mesurée par le méthode Field-MIRE en fonction de la direction du son incident et des bruits du porteur"

Huiwen Goy, University of Toronto (Mississauga)
"Effect of within and between-talker variability on word identification in noise in older and younger adults"

Susan E. Rogers, McGill University
"Memory for Musical Intervals: Cognitive Differences for Consonance and Dissonance"

Gurjit Singh, University of Toronto (Mississauga)
"Auditory Cognitive Attention in Younger and Older Adults: A Comparison of Laboratory and Self-Report Measures"

UNDERWATER AND SIGNAL PROCESSING STUDENT TRAVEL SUBSIDY /
SUBVENTION DE VOYAGE POUR ÉTUDIANT EN ACOUSTIQUE SOUS-MARINE OU
TRAITEMENT DU SIGNAL

Dag Tollefsen, University of Victoria
"Geoacoustic Inversion of Horizontal Line Array Ship-Noise Data from Barents"
Pacific Rim Underwater Acoustic Conference, Vancouver, October 3-5, 2007

CONGRATULATIONS / FÉLICITATIONS

Canadian acoustical Association Annual Conference
CONCORDIA UNIVERSITY
Faculty of Engineering and Computer Science, Montreal, Canada
October 9-12, 2007

The Canadian Acoustical Association Annual Conference, CAA 2007, was held in the attractive new Engineering and Visual Arts Complex of the Concordia University in downtown Montreal. The conference attracted researchers in various fields of Acoustical Sciences and Engineering, and Auditory Perception. The theme for the 2007 conference was **AEROACOUSTICS,** befitting the reputation of Montreal as the "Aerospace Capital of the World". There were three days of parallel sessions on diverse areas of acoustics, including some special sessions on emerging topics as well as an interesting array of industrial exhibits showcasing acoustical applications and products.

A welcome reception for the delegates with live music was held on the evening of October 9, 2007. The conference was inaugurated by Dr. Louise Dandurand, Vice President, Graduate Studies and Research, Concordia University, on October 10, 2007. The opening session was chaired by Dr. Terrel Fancott, Associate Dean, Engineering and Computer Science.

There were plenary lectures on "Jet Noise Prediction: Past Present and Future", by Dr. Philip Morris, Pennsylvania State University, USA, on "Pitch, Proximity, Voice Leading and consonance", by Dr. Dmitri Tymoczko, Princeton University, USA, and on "Innovative Materials for Noise Control in Buildings", by Dr. Franck Sgard, Ecole Nationale des Travaux Publics de l'Etat, France. There were 110 papers with 24 student presentations. The student presentations were judged and 4 awards were given.

The conference was sponsored by the Faculty of Engineering and Computer Science, Concordia University; Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ); Pratt and Whitney Canada; and Bombardier Aerospace.

During the conference there were seven industrial exhibits of acoustical products and services. Those who visited all the exhibits were included in a special draw made during the banquet. The industries that participated in the exhibits are: H.L. Blachford Ltd., B & K North America Inc., Dalimar Instruments, Novel Dynamics Inc., Pyrok Inc., Scantek Inc., and Soft dB.

The conference organizing committee:

Conference Chair: R. Bhat;

Technical Programs Chair: K. Siddiqui;

Exhibits Chair: M. Packirisamy;

Publications Chair: S. Narayanswamy;

Finance Chair: Z. Chen;

Logistics Chair: W. Xie

Special Sessions: Hoi Dick Ng;

Special events: Vijay Devabhaktuni

The responsibility for the conference Proceedings was completely taken by Ramani Ramakrishnan, Editor, Canadian Acoustics Journal. Further, and the coordination of the judging of the student presentations was handled by Christiane Giguére, the CAA Awards Coordinator.

Front row: Hoi Dick Ng, Muthukumaran Packirisamy, Stan Dosso (President - CAA), Vijay Devabhaktuni
Back row: Rama Bhat, Kamran Siddiqui, Sivakumar Narayanaswamy, Wenfang Xie


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The Canadian Acoustical Association
L'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT • ANNONCE DE PRIX

A number of prizes and subsidies are offered annually by The Canadian Acoustical Association. Applicants can obtain full eligibility conditions, deadlines, application forms, past recipients, and the names of the individual prize coordinators on the CAA Website (http://www.caa-aca.ca). • Plusieurs prix et subventions sont décernés à chaque année par l'Association Canadienne d'Acoustique. Les candidats peuvent se procurer de plus amples renseignements sur les conditions d'éligibilités, les échéances, les formulaires de demande, les récipiendaires des années passées ainsi que le nom des coordonnateurs des prix en consultant le site Internet de l'ACA (http://www.caa-aca.ca).

Deadline for Underwater Acoustic and Signal Processing Student Travel Subsidy: **31 March 2008**
Échéance Subvention de Voyage pour Étudiants en Acoustique Sous-marine ou Traitement du Signal: **31 Mars 2008**

EDGAR AND MILLICENT SHAW POSTDOCTORAL PRIZE IN ACOUSTICS • PRIX POST-DOCTORAL EDGAR AND MILLICENT SHAW EN ACOUSTIQUE

$3,000 for full-time postdoctoral research training in an established setting other than the one in which the Ph.D. was earned. The research topic must be related to some area of acoustics, psychoacoustics, speech communication or noise. • $3,000 pour une formation recherche à temps complet au niveau postdoctoral dans un établissement reconnu autre que celui où le candidat a reçu son doctorat. Le thème de recherche doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit.

ALEXANDER GRAHAM BELL GRADUATE STUDENT PRIZE IN SPEECH COMMUNICATION AND HEARING • PRIX ÉTUDIANT ALEXANDRE GRAHAM BELL EN COMMUNICATION VERBALE ET AUDITION

$800 for a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. • $800 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale.

FESSENDEN GRADUATE STUDENT PRIZE IN UNDERWATER ACOUSTICS • PRIX ÉTUDIANT FESSENDEN EN ACOUSTIQUE SOUS-MARINE

$500 for a graduate student enrolled at a Canadian academic institution and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline reliée à l'acoustique sous-marine.

ECKEL GRADUATE STUDENT PRIZE IN NOISE CONTROL • PRIX ÉTUDIANT ECKEL EN CONTRÔLE DU BRUIT

$500 for a graduate student enrolled at a Canadian academic institution and conducting research related to the advancement of the practice of noise control. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche relié à l'avancement de la pratique du contrôle du bruit.

RAYMOND HÉTU UNDERGRADUATE PRIZE IN ACOUSTICS • PRIX ÉTUDIANT RAYMOND HÉTU EN ACOUSTIQUE

One book in acoustics of a maximum value of $150 and a one-year subscription to *Canadian Acoustics* for an undergraduate student enrolled at a Canadian academic institution and having completed, during the year of application, a project in any field of acoustics or vibration. • Un livre sur l'acoustique et un abonnement d'un an à la revue *Acoustique Canadienne* à un(e) étudiant(e) inscrit(e) dans un programme de 1er cycle dans une institution académique canadienne et qui a réalisé, durant l'année de la demande, un projet dans le domaine de l'acoustique ou des vibrations.

CANADA-WIDE SCIENCE FAIR AWARD • PRIX EXPO-SCIENCES PANCANADIENNE

$500 and a one-year subscription to *Canadian Acoustics* for the best project related to acoustics at the Fair by a high-school student • $500 et un abonnement d'un an à la revue *Acoustique Canadienne* pour le meilleur projet relié à l'acoustique à l'Expo-sciences par un(e) étudiant(e) du secondaire.

DIRECTORS' AWARDS • PRIX DES DIRECTEURS

One $500 award for the best refereed research, review or tutorial paper published in *Canadian Acoustics* by a student member and one $500 award for the best paper by an individual member • $500 pour le meilleur article de recherche, de recensement des travaux ou d'exposé didactique arbitré publié dans l'*Acoustique Canadienne* par un membre étudiant et $500 pour le meilleur article par un membre individuel.

STUDENT PRESENTATION AWARDS • PRIX POUR COMMUNICATIONS ÉTUDIANTES

Three $500 awards for the best student oral presentations at the Annual Symposium of The Canadian Acoustical Association. • Trois prix de $500 pour les meilleures communications orales étudiant(e)s au Symposium Annuel de l'Association Canadienne d'Acoustique.

STUDENT TRAVEL SUBSIDIES • SUBVENTIONS POUR FRAIS DE DÉPLACEMENT POUR ÉTUDIANTS

Travel subsidies are available to assist student members who are presenting a paper during the Annual Symposium of The Canadian Acoustical Association if they live at least 150 km from the conference venue. • Des subventions pour frais de déplacement sont disponibles pour aider les membres étudiants à venir présenter leurs travaux lors du Symposium Annuel de l'Association Canadienne d'Acoustique, s'ils demeurent à au moins 150 km du lieu du congrès.

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING STUDENT TRAVEL SUBSIDIES • SUBVENTIONS POUR FRAIS DE DÉPLACEMENT POUR ÉTUDIANTS EN ACOUSTIQUE SOUS-MARINE ET TRAITEMENT DU SIGNAL

One $500 or two $250 awards to assist students traveling to national or international conferences to give oral or poster presentations on underwater acoustics and/or signal processing. • Une bourse de $500 ou deux de $250 pour aider les étudiant(e)s à se rendre à un congrès national ou international pour y présenter une communication orale ou une affiche dans le domaine de l'acoustique sous-marine ou du traitement du signal.

--- FIRST ANNOUNCEMENT ---

ACOUSTICS WEEK IN CANADA

Vancouver, 6 - 8 October 2008

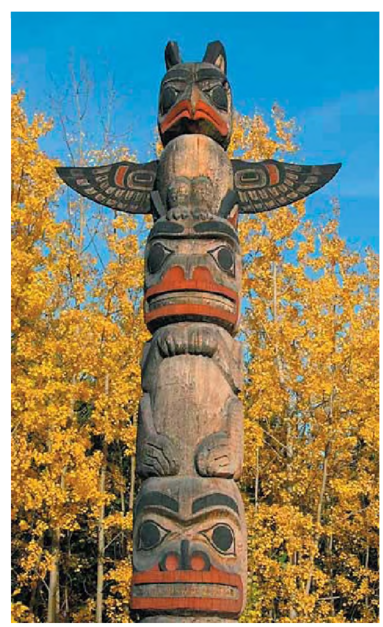
Acoustics Week in Canada 2008, the annual conference of the Canadian Acoustical Association, will be held in Vancouver, British Columbia from 6 to 8 October 2008. This is the premier Canadian acoustical event of the year, and is being held in beautiful, vibrant Vancouver, making it an event that you do not want to miss. The conference will include three days of plenary presentations and parallel technical sessions on a wide range of areas of acoustics, the CAA Annual General Meeting, an equipment exhibition and the conference banquet.

Special Sessions - Special sessions consisting of invited and contributed papers will be organized on a number of topics. If you would like to propose and/or organize a special session in your technical area, please contact the Conference Chair or Technical Co-Chair.

Venue and Accommodation - The conference will be held at the Coast Plaza Hotel & Suites [http://www.coasthotels.com/hotels/canada/bc/vancouver/coast_plaza/overview], in the dynamic West End of downtown Vancouver, steps from the beach at English Bay, walking distance to beautiful Stanley Park and trendy Robson Street, near Granville Island and Chinatown. Participants registering with the hotel will be eligible to receive the reduced room rate of $129/night (single or double). Stay at the conference hotel to be near all activities and your colleagues, and to help make the conference a financial success to the benefit of all CAA members.

Equipment Exhibition - The conference will include a one-day exhibition of acoustical equipment and products. If you are an equipment supplier interested in participating in the exhibition, please contact the exhibition coordinator.

Student Participation - The participation of students is strongly encouraged. Travel subsidies and reduced registration fees will be available. Student presenters are eligible to win prizes for the best presentations at the conference.



Paper Submission - The deadlines for submission of abstracts, and of two-page summaries for publication in its proceedings issue, will be announced in the March issue of Canadian Acoustics.

Local Organizing Committee

- *Conference Chair: Murray Hodgson [murray.hodgson@ubc.ca]*
- *Technical Co-Chair: Kimary Shahin [kns3@sfu.ca]*
- *Venue: Linda Rammage [linda.rammage@vch.ca]*
- *Treasurer: Mark Cheng [mark_cheng@yvr.ca]*
- *Equipment Exhibition: Mark Bliss [bliss@bkl.ca]*
- *Audio/Visual: Christine Harrison [christine.harrison@worksafebc.com]*
- *Student Issues, Translation: Hind Sbini [sbihi@interchg.ubc.ca]*
- *Administrator: Bernadette Duffy [bduffy@interchg.ubc.ca]*

Conference Website: www.caa-aca.ca/vancouver-2008.html

--- PREMIERE ANNONCE ---

SEMAINE CANADIENNE D'ACOUSTIQUE

Vancouver, 6 - 8 octobre 2008

La conférence annuelle de l'Association Canadienne d'Acoustique (ACA) se tiendra à Vancouver en Colombie-Britannique du 6 au 8 octobre 2008. Il s'agit du plus important événement canadien de l'acoustique de l'année, qui aura lieu dans la ville de Vancouver, une des plus pittoresques et vibrantes villes canadiennes. Trois jours de sessions plénières ainsi que des sessions techniques parallèles seront présentées, couvrant un vaste éventail du monde de l'acoustique. La conférence comprendra aussi la réunion annuelle générale de l'ACA, un banquet et l'exposition de divers équipements et produits acoustiques.

Sessions spéciales - Des sessions spéciales seront organisées autour de divers sujets par des conférenciers invités ou par le biais de communications soumises par les délégués. Si vous désirez suggérer un sujet de session spéciale et/ou organiser une de ces sessions, veuillez communiquer avec le président du congrès ou le directeur scientifique.

Lieu du congrès et hébergement - La conférence se tiendra au Coast Plaza Hotel & Suites [http://www.coasthotels.com/hotels/canada/bc/vancouver/coast_plaza/overview], dans le quartier dynamique West End du centre-ville de Vancouver, à quelques pas de la plage de la baie des Anglais (English Bay), à proximité du fameux parc Stanley et de la chic rue Robson, proche du marche populaire de l'île Granville, et du Chinatown. Les délégués seront éligibles à bénéficier d'un tarif préférentiel de $129/nuit (occupation simple ou double). Choisissez cet hôtel pour participer pleinement au congrès, en étant à proximité de toutes les activités et de vos collègues, et pour assurer le succès de la conférence pour le bénéfice de tous les membres de l'ACA.

Exposition technique - Une journée sera consacrée à l'exhibition d'instruments et autres produits de l'acoustique. Si vous êtes un fournisseur d'équipement intéressé de participer, veuillez contacter la personne en charge de la coordination de l'exhibition.

Participation étudiante - La participation des étudiants au congrès est vivement encouragée. Des aides financières pour le déplacement et une réduction pour l'inscription seront mises à disposition. Les membres étudiants qui présenteront une communication seront éligibles pour gagner un prix pour communications étudiantes.

Soumission des présentations - Les échéances pour soumettre vos résumés, et un sommaire de deux pages, seront annoncées dans le numéro du mois de mars de l'Acoustique Canadienne.

Comité d'organisation

- *Président: Murray Hodgson [murray.hodgson@ubc.ca]*
- *Directeur scientifique: Kimary Shahin [kns3@sfu.ca]*
- *Trésorier: Mark Cheng [mark_cheng@yvr.ca]*
- *Exposition: Mark Bliss [bliss@bkl.ca]*
- *Audio-visuel: Christine Harrison [christine.harrison@worksafebc.com]*
- *Affaires étudiantes, Traduction: Hind Sbihi [sbihi@interchange.ubc.ca]*
- *Accommodations: Linda Rammage [linda.rammage@vch.ca]*
- *Administrateur: Bernadette Duffy [bduffy@interchg.ubc.ca]*

Site Web de la conférence: www.caa-aca.ca/vancouver-2008.html

INSTRUCTIONS TO AUTHORS FOR THE PREPARATION OF MANUSCRIPTS

Submissions: The original manuscript and two copies should be sent to the Editor-in-Chief.

General Presentation: Papers should be submitted in camera-ready format. Paper size 8.5” x 11”. If you have access to a word processor, copy as closely as possible the format of the articles in Canadian Acoustics 18(4) 1990. All text in Times-Roman 10 pt font, with single (12 pt) spacing. Main body of text in two columns separated by 0.25”. One line space between paragraphs.

Margins: Top - title page: 1.25”; other pages, 0.75”; bottom, 1” minimum; sides, 0.75”.

Title: Bold, 14 pt with 14 pt spacing, upper case, centered.

Authors/addresses: Names and full mailing addresses, 10 pt with single (12 pt) spacing, upper and lower case, centered. Names in bold text.

Abstracts: English and French versions. Headings, 12 pt bold, upper case, centered. Indent text 0.5” on both sides.

Headings: Headings to be in 12 pt bold, Times-Roman font. Number at the left margin and indent text 0.5”. Main headings, numbered as 1, 2, 3, ... to be in upper case. Sub-headings numbered as 1.1, 1.2, 1.3, ... in upper and lower case. Sub-sub-headings not numbered, in upper and lower case, underlined.

Equations: Minimize. Place in text if short. Numbered.

Figures/Tables: Keep small. Insert in text at top or bottom of page. Name as “Figure 1, 2, ...” Caption in 9 pt with single (12 pt) spacing. Leave 0.5” between text.

Line Widths: Line widths in techincal drawings, figures and tables should be a minimum of 0.5 pt.

Photographs: Submit original glossy, black and white photograph.

Scans: Should be between 225 dpi and 300 dpi. Scan: Line art as bitmap tiffs; Black and white as grayscale tiffs and colour as CMYK tiffs;

References: Cite in text and list at end in any consistent format, 9 pt with single (12 pt) spacing.

Page numbers: In light pencil at the bottom of each page. Reprints: Can be ordered at time of acceptance of paper.

DIRECTIVES A L’INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

Soumissions: Le manuscrit original ainsi que deux copies doivent être soumis au rédacteur-en-chef.

Présentation générale: Le manuscript doit comprendre le collage. Dimensions des pages, 8.5” x 11”. Si vous avez accès à un système de traitement de texte, dans la mesure du possible, suivre le format des articles dans l’Acoustique Canadienne 18(4) 1990. Tout le texte doit être en caractères Times-Roman, 10 pt et à simple (12 pt) interligne. Le texte principal doit être en deux colonnes séparées d’un espace de 0.25”. Les paragraphes sont séparés d’un espace d’une ligne.

Marges: Dans le haut - page titre, 1.25”; autres pages, 0.75”; dans le bas, 1” minimum; latérales, 0.75”.

Titre du manuscrit: 14 pt à 14 pt interligne, lettres majuscules, caractères gras. Centré.

Auteurs/adresses: Noms et adresses postales. Lettres majuscules et minuscules, 10 pt à simple (12 pt) interligne. Centré. Les noms doivent être en caractères gras.

Sommaire: En versions anglaise et française. Titre en 12 pt, lettres majuscules, caractères gras, centré. Paragraphe 0.5” en alinéa de la marge, des 2 cotés.

Titres des sections: Tous en caractères gras, 12 pt, Times-Roman. Premiers titres: numéroter 1, 2, 3, ..., en lettres majuscules; sous-titres: numéroter 1.1, 1.2, 1.3, ..., en lettres majuscules et minuscules; sous-sous-titres: ne pas numéroter, en lettres majuscules et minuscules et soulignés.

Equations: Les minimiser. Les insérer dans le texte si elles sont courtes. Les numéroter.

Figures/Tableaux: De petites tailles. Les insérer dans le texte dans le haut ou dans le bas de la page. Les nommer “Figure 1, 2, 3,...” Légende en 9 pt à simple (12 pt) interligne. Laisser un espace de 0.5” entre le texte.

Largeur Des Traits: La largeur des traits sur les schémas technique doivent être au minimum de 0.5 pt pour permettre une bonne reproduction.

Photographies: Soumettre la photographie originale sur papier glacé, noir et blanc.

Figures Scanées: Doivent être au minimum de 225 dpi et au maximum de 300 dpi. Les schémas doivent être scannés en bitmaps tif format. Les photos noir et blanc doivent être scannées en échelle de gris tifs et toutes les phoots couleurs doivent être scannées en CMYK tifs.

Références: Les citer dans le texte et en faire la liste à la fin du document, en format uniforme, 9 pt à simple (12 pt) interligne.

Pagination: Au crayon pâle, au bas de chaque page. Tirés-à-part: Ils peuvent être commandés au moment de l’acceptation du manuscrit.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $65.00 for individual members and $25.00 for Student members. This includes a subscription to ***Canadian Acoustics***, the Association's journal, which is published 4 times/year. New membership applications received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available. New membership applications received after August 31 will be applied to the next year.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to ***Canadian Acoustics*** are available to companies and institutions at the institutional subscription price of $65.00. Many companies and institutions prefer to be a Sustaining Subscriber, paying $300.00 per year, in order to assist CAA financially. A list of Sustaining Subscribers is published in each issue of ***Canadian Acoustics***. Subscriptions for the current calendar year are due by January 31. New subscriptions received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available.

Please note that electronic forms can be downloaded from the CAA Website at **caa-aca.ca**

Address for subscription / membership correspondence:

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Address ______________________________

City/Province ______________ Postal Code __________ Country ______________

Phone ______________ Fax ______________ E-mail ______________

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Areas of Interest: (Please mark 3 maximum)

1. Architectural Acoustics
2. Engineering Acoustics / Noise Control
3. Physical Acoustics / Ultrasound
4. Musical Acoustics / Electro-acoustics
5. Psychological / Physiological Acoustic
6. Shock and Vibration
7. Hearing Sciences
8. Speech Sciences
9. Underwater Acoustics
10. Signal Processing / Numerical Methods
11. Other

For student membership, please also provide:

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Mail application and attached payment to:

D. Quirt, Secretary, Canadian Acoustical Association, PO Box 74068, Ottawa, Ontario, K1M 2H9, Canada

l'Association Canadienne d'Acoustique
The Canadian Acoustical Association

Formulaire d'adhésion

L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 65.00$ pour les membres individuels, et de 25.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Abonnement pour la revue *Acoustique Canadienne* et abonnement de soutien

Les abonnements pour la revue ***Acoustique Canadienne*** sont disponibles pour les compagnies et autres établissements au coût annuel de 65.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 300.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue ***Acoustique Canadienne***. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Pour obtenir des formulaires electroniques, visitez le site Web: **caa-aca.ca**

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Cocher vos champs d'intérêt: (maximum 3)

1. Acoustique architecturale
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Prière de remplir pour les étudiants et étudiantes:

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Cocher la case appropriée:

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Prière d'attacher votre paiement au formulaire d'adhésion. Envoyer à :

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The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

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L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissant les coûts de publication et de distribution, les dons annuels (de $300.00 et plus) rendent le journal accessible à tous nos membres.

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